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USE AND ABUSE OF ENGLISH IN SCIENCE

EXPOSITION by the spoken or the written word is a skill which is not easily acquired; and judging from the adverse comments made on the efforts of scientific men for many years past, they have been particularly unfortunate in this field. Yet a little reflexion will show that they are not alone in finding difficulty in conveying to others, even those of similar interests, their thoughts and views. So far as writing is concerned, the acknowledged masters spend a life-time practising their art. Such skill, partly a natural gift and partly acquired, is given to few; but that is no reason why others should not strive to set down their thoughts in clear and pleasing terms.

Scientific men have a double task: they have to describe their work to laymen and also to other scientists—sometimes those working in very different fields. Yet this task is not really a double one; there is fundamentally only a difference of emphasis. The same qualities of clarity, simplicity and accuracy are still of major importance.

In an article on p. 851 of this issue of *Nature*, Dr. John R. Baker takes scientific men to task specifically for the way in which their papers are written and are presented. Thus he is narrowing down the general issue, though it could be expected that any improvement in this particular respect would quickly have beneficial effects elsewhere. It is, of course, by no means a novelty to complain that many scientific men write in an uncouth and slovenly style; that complaint has been a common topic of discussion by directors of research for many years. It was indeed a factor in the discussions at the older universities a few years ago on the desirability of retaining at least one of the ancient languages in the entrance requirements. The argument was that, quite apart from any possible usefulness of the fleeting acquaintance with the classics and ancient history thus acquired, there was considerable value in the discipline of translation and the knowledge of the meaning of words and their roots which were acquired. Whether or not a limited knowledge of Latin and Greek is beneficial from this point of view, it is worth noting that the university members of the Committee of Vice-Chancellors and Principals in the recent report on university entrance requirements still commented on the inadequate command of English shown by many of those seeking to enter a university. This topic was also mentioned by Dr. R. P. Linstead in his recent inaugural address as rector of the Imperial College of Science and Technology.

Some specific points are, however, made by Dr. Baker which merit immediate consideration. After mentioning grammatical errors, he turns to what he terms "grandiloquence". Here, in passing, attention may be directed to the letter by Prof. H. N. Barber in *Nature* of October 15, p. 750, which surely needs no comment. It will, of course, be agreed that where certain terms or phrases have a specific technical meaning, they must be used. Even so, it is not a bad thing to consider from time to time whether their continual use in the course of perhaps a single paragraph, however justifiable on the grounds of accuracy, does not lay the writer open to the charge of using technical jargon. It is clearly a point on which a certain amount of thinking is necessary.

On the question of the use of a German construction for the sequence of adjectives and nouns, Dr. Baker is probably right in stating that the practice is growing. In some cases—and Dr. Baker quotes examples—only the judicious use of the occasional hyphen can save a phrase from meaning the reverse of what is intended; the meaning may still be obvious from the context, but it should not be necessary to have to go to the context in such short phrases. It is difficult to find any real justification for the use of this style. To a limited extent it may give crispness to a statement and save the use of the word 'of'; but its general adoption seems dangerous and unnecessary. Dr. Baker's examples could readily be multiplied, and point to the growth of a new style in scientific writing which has nothing to commend it.

Passing now beyond Dr. Baker's article, reference may be made to another tendency—perhaps it is only a mannerism—which has been noticed in recent years, namely, an unusual use of some common verbs. Thus an author may write that he "reacted zinc with hydrochloric acid", or he "combusted" something, or that "a metal distorts upon cooling", or that "a wave propagates in a straight line". Such phrases are frequently seen in communications submitted to *Nature*, from Great Britain as well as elsewhere, and sometimes it is difficult to be sure whether or not a new technical meaning is being given to a hitherto common word. Unless some particular quality is intended by the use of common words in this way, it would seem that an unnecessary grammatical change is being introduced. The English language, in spite of its lack of inflexions, is wonderfully fluid and surely does not need to be subjected to such twists in order to accommodate new terms or to re-express old ones.

Another problem which is causing increasing concern—to printers as well as to editors—is the frequent and indiscriminate use of abbreviations in the form of a single capital letter, or a group of capitals, to represent the name of a substance, or perhaps even an adjective or adverb. The printer is concerned because a page of text sprinkled with capital letters is not pleasing in appearance; and, like other craftsmen, he feels that his efforts are being frustrated. It may be argued that this is of no concern to the scientist; but surely his work is worthy of good presentation, and there is satisfaction and even advantage in recording the results of research in an elegant style.

So far as the use of abbreviations themselves is concerned, the subject was discussed some time ago in these columns. As was pointed out then, a little

consideration will show that abbreviations can often be replaced by pronouns without loss of clarity or accuracy. No one writing for the general reader would willingly use the same noun several times in a single sentence; yet when abbreviations or symbols are adopted, there seems to be no hesitation in repeating them—often as many times as possible. Biochemists are great offenders in this respect, and their excuse must be that many of the substances they use have unwieldy names. Similarly, organic chemists are hampered by a cumbersome nomenclature, which however admirable from the point of view of describing a substance, invites the use of abbreviations; indeed, the industrial organic chemist has found it necessary to invent names or use specific symbols like DDT for the sake of the users of his products. But a sense of proportion must be maintained in devising and using specialized terms; thus it seems pointless to write *p*-ClHgBA for *p*-chloromercurobenzoate, and positively dangerous to use H for histidine. The habit—for it is little else—of introducing abbreviations is now spreading through physical chemistry to physics and to mathematics; indeed, to all sciences. Thus E has been used for 'enzyme', with the derived symbols ES for 'enzyme substrate' and ESI for enzyme substrate inhibitor, and M.O. for molecular orbital; and what is the physicist to think when he finds a plentiful sprinkling of the term MIT on a page, only to find on careful reading that it is an abbreviation for monoiodotyrosine and not the Massachusetts Institute of Technology? Then, again, can the use of ARG for autoradiograph be justified? Mathematical signs occasionally appear in a line of text, especially the sign for 'is equal to'. These examples are taken from manuscripts submitted to *Nature*, and many others might readily be quoted.

It may be claimed that, if an author writes out the name or term, followed by his chosen abbreviation, on the first occasion of its use, or includes a list of the abbreviations he proposes to use, then he is justified in employing his abbreviations throughout the remainder of that particular piece of writing. But is every scientific communication to have its own glossary? Consider the confusion—and additional space required—which would occur in a journal such as *Nature*, in which two dozen or so specialized communications appear every week. The fact is that these abbreviations are, in the main, laboratory and notebook shorthand, or even slang, very valuable in their proper place, but nevertheless a new language, which at present does not seem suited for the considered statement offered for discussion and appraisement by other workers.

The use of abbreviations, especially initial letters, is now becoming so fashionable among scientists that one suspects authors sometimes go out of their way to use them; for example, SV for seminal vesicle. With the increased sliding growth among the various disciplines of science, resulting in such departments of research as biochemistry and biophysics, this fashion may, if not checked, defeat its own ends and produce a veritable 'Tower of Babel'. Indeed, the time does not seem far away when high-school pupils will have to learn a new table of symbols apart from those atomic.

A further problem, which may not occur to most writers, has to be faced in the preparation of an index. Abbreviations or initials sometimes occur alphabetically in quite a different position from that which would be occupied by a full term, thus causing confusion during reference.

Dr. Baker begins his article by disclaiming any intention of setting himself up as a stylist; and in taking up various points he makes, and adding others, we must make a similar disclaimer. Much of what has been said is clearly a matter of opinion, and those holding strong views are unlikely to be converted. Nevertheless, the mode of presenting scientific results has been criticized over a long period of years, and it behoves scientists to give the matter careful attention and to consider whether they can, by dint of a little more care and thought, free themselves of the charge of talking and writing jargon. In the present age, the promotion and exposition of research can be almost as important as the work itself.

SCIENCE AND THE HUMANITIES

Science and the Human Imagination

Aspects of the History and Logic of Physical Science. By Dr. Mary B. Hesse. Pp. 171. (London: Student Christian Movement Press, Ltd., 1954.) 12*s.* 6*d.* net.

IT is surely one of the most significant features of our generation that not only are we contemporary with a flood of new scientific discovery which has already changed the pattern of our physical life, and is rapidly changing the pattern of our thinking, but we are also very conscious of the need to understand this strange new activity called science and to assess its real status and its relationship with other great movements of the human spirit. This little book by Dr. Mary Hesse, herself a mathematician in the University of Leeds, is an attempt to answer the questions: What is science? Is it something fixed and determinate, or is it variable and responsive to the thought-forms of its day? What right have we to say that science is a true account of the natural order? And how is the scientific method related to art and religion?

Dr. Hesse deals with these questions in two stages. First she describes the changing models of science, and shows how the tumultuous flow of new discoveries in physics, from the electron in 1897 to the new quantum theories of 1926, have made old models no longer tenable, and forced us to see what ought indeed to have been recognized all the time, that our models and concepts are, after all, only models and concepts the suitability of which to represent the inaccessible 'things-in-themselves' must be judged by each generation according to the criteria accepted at the time; they can never be final, and they always involve imagination and intuition. One of the most valuable sections of this part of the book is where the author urges a return to the old schoolmen's way of argument 'by analogy', supplementing our more conventional recognition of identity and difference. For argument by analogy involves us in an act of response to our environment wider and

more generous than that which men of science have sometimes claimed, and at the same time it joins them with the artist and the poet.

In the second half of the book, Dr. Hesse deals with the status of scientific theory. She is much attracted to the operational view, according to which all that we may rightly ask or expect of science is an answer to the question: What will happen to this if I do that? All explanations, or interpretations, are unnecessary, unprovable and probably meaningless! With this in mind, she criticizes Eddington and Dirac because many of their concepts are not definable in terms of direct measurement, and what they call 'observables' are by no means always observable. But the author admits that this will not do, for there is an element of awareness in scientific work which makes us feel that we do indeed grapple with something real, however inadequately it may be conveyed to us in our current models.

In some ways this is the weaker half of the book, and it is hard not to feel that Dr. Hesse is still a little uncertain in her own mind. Thus, when she comes to the end of the book and asks about a possible synthesis of science and religion, all she can say is that "there is no satisfying synthesis . . . this side of the Kingdom of God"; and when she asks if any transcendental faith can be accepted with conviction in the modern world, she replies that the question must "remain unanswered until it comes spontaneously from the quality of life of the Christian community". But surely the whole activity of science is a silent witness to a transcendental faith—in a reality so exciting that it commands our study, and so deeply other than us, that we never get beyond the world of model and concept to represent it. I cannot myself escape the conviction that this part of the book would have been more convincing if more biology and less physics were incorporated in it, and if more questions had been asked about man-the-scientist as well as those about the nature of scientific studies. But this is a very readable book, and a stimulating one, which certainly carries the argument further than some of the other fairly recent popular expositions of science have done. We can even excuse a few scientific inaccuracies in face of the extreme honesty of the whole approach, and the recognition that science, art and religion have each their part to play in the satisfactions of human living. C. A. COULSON

RECEPTORS AND SENSORY PERCEPTION

Receptors and Sensory Perception

A Discussion of Aims, Means, and Results of Electrophysiological Research into the Process of Reception. (Mrs. Hepsa Ely Silliman Memorial Lectures.) By Dr. Ragnar Granit. Pp. xii+369. (New Haven, Conn.: Yale University Press; London: Oxford University Press, 1955.) 5 dollars; 40*s*. net.

AN indolent reviewer might claim that there is really no need for him to do more than direct attention to the full title of this book. It is about "Receptors and Sensory Perception", and it is the substance of the Silliman Lectures which Prof. Ragnar Granit gave at Yale in 1954. It is therefore an up-to-date presentation of one of the growing-points of neurophysiology, composed for a scientific, but not necessarily biological, audience by one who is an acknowledged expert in the field he has to cover.

Scientists ought not to need reminding of the quality of Silliman Lectures or of the debt which we all owe to the Silliman Foundation. It has induced a long list of the foremost investigators to emerge from their laboratories to put on record the general theme of their work. Some of the earlier books in the series, like those by J. J. Thomson and Rutherford, are now out of print; but most of them have been milestones. Some have been reprinted and have lost none of their impact, like Sherrington's "Integrative Action of the Nervous System"; but there can be very few of them which have not greatly influenced the progress of scientific work in the twentieth century.

Ragnar Granit's own contributions to the physiology of vision have been a constant inspiration for many years, and he has already brought them together in 1947 in his book on the retina. Here, however, they can be seen in less detail but in better perspective against the general background of sensory physiology. In the earlier chapters, for example, he gives an excellent account both of the older work on the discharge of impulses from sensory end organs and of the recent developments in the study of cutaneous receptors and the function of different kinds of receptor structure and peripheral nerve fibre. Zotterman's recent work on thermoreceptors is well described, and, if we are still left in doubt about the nervous mechanism of pain, it is not Granit's fault that the evidence is still incomplete.

The chapters on the nervous organization of the retina will naturally be read with the greatest attention by all who are concerned with the problem of colour vision, and they will find a clear statement and defence of Granit's dominator–modulator theory. For the general physiologist, however, the concluding chapters on the muscle receptors are perhaps the most interesting, for here we can see how even the most straightforward kind of receptor is subject to a constant adjustment by the central nervous system to make it provide the right kind of information.

In fact, it is not praising Granit's book too highly to say that it is a worthy contribution to the series of Silliman Lectures. ADRIAN

INTERNATIONAL CO-ORDINATION OF GALACTIC RESEARCH

Co-ordination of Galactic Research

Edited by A. Blaauw. (International Astronomical Union Symposium No. 1, held at Groningen, 22–27 June, 1953.) Pp. viii+59. (Cambridge: At the University Press, 1955.) 7*s*. 6*d*. net.

RESEARCH into the nature of the stellar system in which we live has always formed a very considerable part of astronomy; but during the past ten years notable advances arising from a number of new techniques and ideas have greatly stimulated interest in this field. Among the new techniques radio astronomy has had resounding success, especially in dealing with interstellar matter, and is still producing a great flow of important new results. It is true that many of the radio observations have as yet no clear interpretation, but we believe that we now have the tools to map the spirals of the Milky Way,

and to gain great insight into the dynamical structure of the whole system. Simultaneously, the older optical methods have been strengthened by the use of Schmidt telescopes, especially with narrow-pass filters or objective prisms, bringing us a wealth of new data relating to both stars and interstellar material. Equally important improvements in other practical techniques, for example, in photoelectric photometry, are also playing a great part in galactic research.

There has in addition been a ferment of new theoretical ideas. Baade's suggestion that there are two distinct stellar populations in the Milky Way is growing into a more general concept of families of stars having as much as a thousand-fold range in life-times and reaching a corresponding variety of stages in evolution, whether viewed as individual producers of energy from nuclear sources or as particles in the general dynamics of the galaxy. That graveyard of stellar evolution theories, the Hertzsprung–Russell diagram, has now assumed greater significance and greater complexity than ever before. Undismayed by the revelation of these and other complications, theorists are pressing on with their studies of stellar interiors, attempting to compute the evolutionary changes to be expected in stars as a result of the burning of hydrogen or other nuclear fuels.

Concurrently with rapid advances in our knowledge of the Milky Way system and of similar nearby systems such as the Andromeda spiral nebula *M*31, there has been a proliferation of new problems urgently needing investigation. But there has been little increase in the available labour force to deal with these; indeed, an insatiable demand for young scientists from other subjects has made it increasingly difficult to maintain the supply of competent astronomers even at its present modest level. In a situation of too many problems and too few astronomers, one method is to restrict attention to the more outstanding problems and to proceed as far as possible by a careful, but very limited, sampling of the sky. One of the chief purposes of the conference reported in this volume was to discuss ways by which this could be done.

The conference was organized by a sub-committee of the International Astronomical Union's Commission on Stellar Statistics and was largely inspired by Prof. J. H. Oort, himself one of the leading authorities on galactic research. The report gives a very useful summary of work in progress at the date of the meeting, June 1953, and many suggestions for the more urgent programmes of further research. It confines itself for the most part to the standard techniques of optical astronomy, studies of variable stars, photometric measurements of various kinds, spectrum classification, proper motions, radial velocities, etc.

This is one of the first astronomical books in which the term 'man-hours' occurs, in my opinion a belated appearance. Observational astronomy is peculiar in the enormous numbers of objects requiring investigation and the slowness with which the desired information can be collected. A great deal of the work now waiting to be done might quite well have been started thirty years ago, and the need was doubtless in part already understood then. The chief reason why so much has not yet been properly begun is the same reason why the *Carte du Ciel* has never been finished: there is a lack of man-power for routine work which requires persistence and precision above the ordinary, but can sometimes be tedious and dull, which gives results of essential importance but nevertheless brings little thanks or recognition from the scientific community. Looking at twentieth-century astronomical history, one wonders how many of the programmes suggested in this report will be completed in thirty years time.

The widespread use of automatic machinery in industry and its appearance in other fields of scientific research have turned the thoughts of some astronomers to its application to routine astronomical programmes. In principle, this seems quite possible; but as every engineer knows, there is a very long step from designing a machine in principle to bringing it into successful and reliable operation. Not all astronomical programmes could be attacked in this way, and even successful machinery would have serious limitations; but we may be forced to a choice between an adequate volume of machine-made results or next to no results at all. The conference, however, appears to have stuck to well-established methods and to have given little thought to such developments.

I must confess to some pessimism with regard to our ability to finish urgent tasks in galactic research by existing methods, but nevertheless can strongly recommend this volume to anyone seriously interested in Milky Way problems. It should be compulsory reading for British optical astronomers, the great majority of whom have in recent years tended to lose touch with this important branch of their subject, despite the notable achievements of their radio colleagues.

R. O. Redman

MATHEMATICAL TABLES OF THE NATIONAL BUREAU OF STANDARDS, WASHINGTON

United States Department of Commerce: National Bureau of Standards

Tables of Functions and of Zeros of Functions: Collected Short Tables of the National Bureau of Standards Computation Laboratory. (Applied Mathematics Series—No. 37.) Pp. x+211; 2.25 dollars.

Table of Salvo Kill Probabilities for Square Targets. (Applied Mathematics Series—No. 44.) Pp. ix+33; 30 cents.

Tables of the Error Function and Its Derivative. (Applied Mathematics Series—No. 41.) Pp. xi+302; 3.25 dollars.

(Washington, D.C.: Government Printing Office, 1954.)

THE first of these three volumes brings together eighteen short tables of functions and of zeros of functions, most of which have appeared before in various periodicals, three only being new publications. Among others, it contains the integrals of the two Bessel functions of zero order over ranges from 0 to 8·50; $\int_1^\infty e^{-xu}u^{-n}du$, x ranging from 0 to 10 and n from 0 to 20 through integers; Struve functions; Fourier coefficients up to order 100 of powers of x up to x^{10}; sines and cosines for radian arguments between 100 and 1,000; and $x^n/n!$ for x up to 10 and n up to 40 in integers. As regards the tables of zeros, there are included those of the Legendre polynomials of order 1–16, the first fifteen Laguerre polynomials, Bessel functions of simple fractional orders, and their derivatives, and the first ten complex zeros of $\sin z - z$. Explanatory formulæ and bibliographical references are given in all cases.

The second volume, "Table of Salvo Kill Probabilities for Square Targets", contains thirty-three pages devoted entirely to the tabulation of a single probability function defined as a double exponential integral extended over a square. It is considered as a function of five independent parameters, each of which has several representative selected values, the last being the number of missiles released in salvo up to a maximum of two hundred, and the others being concerned with the dispersion and the assumed lethal probability of a single missile. The significance of these parameters is explained in detail in the introduction.

The third work, "Tables of the Error Function and its Derivative", is of considerable extent and first appeared in 1941 under the title of Mathematical Table 8. Apart from a short subsidiary section, it is entirely concerned with the tabulation of the normalized error-function

$$\frac{2}{\sqrt{\pi}}\int_0^x \exp(-\alpha^2)d\alpha$$

and its derivative $\frac{2}{\sqrt{\pi}}\exp(-x^2)$.

All the entries are to fifteen decimal places, and the ranges of x are 0 to 1 at intervals of 0·0001, 1 to 5·6 at intervals of 0·001, and a few subsequent values between 5·6 and 6. In the last range the differences between the two functions and 1 and 0, respectively, are of course extremely small, affecting only the fourteenth and fifteenth decimal places. In the short supplementary table (previously mentioned), these differences are given to eight significant figures for x between 4 and 10 at 0·01 intervals with their appropriate inverse powers of 10, the last of which is 10^{-45}. Eleven pages of introduction include details of the methods used in computing and checking the tables and a bibliography. J. H. Pearce

PHYSIOLOGY IN COLD CLIMATES

Man in a Cold Environment

Physiological and Pathological Effects of Exposure to Low Temperatures. (Monographs of the Physiological Society—No. 2.) By Prof. Alan C. Burton and Prof. Otto G. Edholm. Pp. xiv+273. (London: Edward Arnold (Publishers), Ltd., 1955.) 30*s*. net.

THIS book on the "Physiological and Pathological Effects of Exposure to Low Temperatures" has been written under the joint authorship of a biophysicist and a physiologist, and is the second of a series of monographs of the Physiological Society. The authors are to be congratulated on making readily available for the first time information largely derived from research carried out for the Armed Services. During and just after the Second World War a very considerable amount of literature accumulated, which the authors have examined and presented in a very readable form, together with the conclusions which they have drawn with great care and restraint from the varying points of view. There are both author and subject indexes, and at the end of each chapter very full references are given. The text is admirably illustrated with charts and diagrams. The first part of the monograph deals with the physical laws governing the interchange of heat between man and his environment. Towards the end of this section the authors make the important point that "In almost every case of the general problem of enabling men to survive and function efficiently in adverse environments as at high altitude, the answer to the problem proved to be in the field of engineering, rather than in modifying human physiology"; however, "the engineering answer is not perfected without the fundamental knowledge of the underlying physiology".

The next three chapters discuss the insulation afforded by the air, the clothing and the tissues of the body. Man has been able to extend his sphere of activity both in hot and in cold climates by the use of clothes; but as yet no really satisfactory means of protecting the face has proved practical, and the exposed regions of the body play an important part in determining the 'tolerance time' of a particular clothing assembly. The chapter on the estimation of the thermal demand sets out the variables other than temperature that can affect the heat loss of the human body, and a 'unitary estimate' of these varying factors such as wind chill, corrected effective temperature, solar radiation, and radiation increment, can be introduced as a correction factor to the environmental temperature, and an estimate of the clothing requirements obtained from a single parameter. The chapter on the possibilities of maintaining a thermal steady state in the cold deals also with comparative physiology, and it is pointed out that "A survey of what methods of compensation are actually used by animals in cold environments is most useful, since it permits us to explore the possibilities of further exploitation of methods of compensation, which have not been fully utilized by animals".

Shivering is discussed under the heading of the metabolic response to cold. Recent work has shown that there is an increased 'thermal muscular tone' prior to the onset of shivering; but the question of extramuscular metabolic increments in response to cold is still open, as a great deal of evidence both for and against this increment has been produced. There is an increased voluntary dietary intake in response to cold; but so far no simple explanation of this response has been found to be tenable. Acclimatization to cold is considered under general bodily changes and local changes. There is some evidence against acclimatization to cold, and it would seem that any acclimatization sustained is only of short duration when compared with that in response to chronic exposure to heat.

Hypothermia, both chronic and acute, is discussed, and the consensus of opinion as regards the treatment of these conditions is that: rapid rewarming should be carried out in cases of acute hypothermia, and rapid rewarming with correction of the body fluid balance and administration of glucose for cases of chronic hypothermia; moderate rewarming is to be condemned. The various pathological changes taking place in response to local cold injury are discussed, and it is considered that "there is a great need for more detailed studies in this field which profitably could include more precise definition of the conditions necessary to produce mild injury".

The last chapter of the monograph very appropriately deals with problems for future research, and must act as a stimulus to those who are apt to think that this branch of climatic physiology lies dormant except in times of national emergency. The monograph is a valuable storehouse of information and should be read by everyone who is interested in the physiology of cold climates. J. R. Brown

Michael Faraday

Man of Simplicity. By Prof. James Kendall. Pp. 196+4 plates. (London: Faber and Faber, Ltd., 1955.) 12*s.* 6*d.* net.

THERE is no resisting Prof. James Kendall. He begins at a disadvantage, for one picks up his book with the thought that this is another small book about Faraday, of which there are already rather too many. Then it is a little disconcerting to meet in the early pages a sentence such as this: "Humphry invited Michael to come to the Royal Institution for an interview". Despite the author's apology, this familiar mode of address of the two principal characters seems unnecessary, and it assorts rather oddly in passages where third persons, for example Wollaston, are accorded the more formal surname. There is, also, to one reader at least, some over-emphasis on the 'simplicity' of Faraday's nature. Simplicity and ingenuousness had their place in a complex character; but to stress them unduly is to give a false impression of the man as a whole.

Personal prejudices on points of this kind are, however, forgotten after a few chapters, and the reader finds himself swept along on the tide of Prof. Kendall's enthusiasm. The treatment of Faraday's scientific work does not pretend to be very full or comprehensive; but the story of his life is admirably and sympathetically told, the significance of the principal researches is brought out in the narrative, and the result is a very readable book. It is, incidentally, to anyone who has heard Prof. Kendall lecture on the subject, a delightful reminder of the lecturer.

Atoms in the Family

My Life with Enrico Fermi—Designer of the First Atomic Pile. By Laura Fermi. Pp. 284+15 plates. (London: George Allen and Unwin, Ltd., 1955.) 18*s.* net.

ONE could wish that every great scientist had a wife with such literary skill and sense of humour as Mrs. Laura Fermi. Her book is much more than just a biography of her famous husband, the late Enrico Fermi, though naturally he is the chief person in it. It gives snatches from his childhood and from his life as a student and young professor, unpretentiously written against a background of the Italian scene and the rising of Fascism. From there the narrative moves to the United States and those—for her—most puzzling years 1939–45 in which Fermi, though still technically an enemy alien, moved about between New York, Chicago and Los Alamos on mysterious errands. Only when the atom bomb had blasted the veil of secrecy did Mrs. Fermi and the other wives of scientists find out that the first atomic pile had come into operation three years previously, and that Fermi had been one of the leading minds in that stupendous enterprise which resulted in Hiroshima and Nagasaki.

But Mrs. Fermi keeps an admirable balance between the great events around which her life had to shape itself and the small everyday things of which that life consisted. She is a good observer of people, and her pen-portraits are admirable. Many of the people I knew in Los Alamos have come to life again for me through her shrewd observations. Nor does that shrewdness desert her when it comes to describing her own husband. He lives in these pages as his friends knew him—admirable but not faultless, and likeable even in his faults.

Naturally, the book should not be considered as material for the historian, but practically all the scientific facts she quotes are correct (and, by the way, admirably presented for the non-scientist), and I have found only a few minute and quite irrelevant inaccuracies in the events she writes about. This is a human, engaging and entertaining book, written at a time when Fermi was still in good health, before the illness which caused his untimely death soon afterwards.

O. R. Frisch

The Botany of Cook's Voyages and Its Unexpected Significance in Relation to Anthropology, Biogeography and History

By Prof. Elmer Drew Merrill. (Chronica Botanica, Vol. 14, Number 5/6.) Pp. iv+161–384+plates 80–92. (Waltham, Mass.: The Chronica Botanica Co.; London: Wm. Dawson and Sons, Ltd., 1954.) 4.75 dollars (cloth).

DR. MERRILL is a systematist and plant geographer of great seniority. In this curious and uneven book he examines the herbaria collected on Captain Cook's first and second voyages. His main purpose is to decide to what extent there was a diffusion of crop plants, weeds and cultures across the Pacific Ocean between America and Asia before Magellan's voyage in 1520. This is a problem which has for a long time interested scholars, and it has recently been popularized through the Kon-Tiki expedition and the writings of T. Heyerdahl.

There undoubtedly is room for further critical discussion of the botanical evidence for and against the early blending of American and Polynesian cultures. But such a discussion would need to be objective, urbane, and free from prejudices and polemics and innuendoes about the competence of other workers in the field. Dr. Merrill's book fulfils none of these requirements. One must only regret that in this book Dr. Merrill's knowledge and experience have been deployed in a manner which does not enlist the confidence of the reader nor illuminate the subject.

E. Ashby

Optics

By Arnold Sommerfeld. (Lectures on Theoretical Physics, Volume 4.) Translated by Otto Laporte and Peter A. Moldauer. Pp. xiii+383. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1954.) 6.80 dollars.

THE appearance in English of this part of Sommerfeld's lectures on theoretical physics is a very welcome addition to the literature. In Sommerfeld's course of lectures, theoretical optics formed an important section which does not correspond to any definite course in most British universities. In Britain the material, in so far as it is treated, would usually be found either in a course on electromagnetic theory in general, which would not allow time for detailed treatment of many optical problems, or in a course on physical optics, which usually includes less of the mathematical theory. This text by one of the masters in the mathematical treatment of wave problems will nevertheless be valuable for use with courses of both kinds and of great help to those who want to take optics further than the normal undergraduate teaching permits.

As in the other volumes, the use of powerful mathematical techniques is presented and applied without losing sight of the physical ideas behind them, or of the fact that one is dealing with knowledge which, in the last resort, is derived from experiment.

R. E. Peierls

ENGLISH STYLE IN SCIENTIFIC PAPERS

By Dr. JOHN R. BAKER
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MANY scientific papers published in Great Britain are written in a style quite different from that adopted by good English authors. There would be no disadvantage in that, if an improved version of our language had been invented for scientific papers. This, however, is not so. For clarity and directness one must turn to non-scientific authors. One hesitates to direct attention to this subject lest one be accused of setting oneself up as a stylist. There is no such intention here. It is proposed merely to suggest a few ways in which scientific papers could be made simpler, clearer, and more pleasant to read.

To prevent any misunderstanding, it must be remarked at the outset that it is no part of my purpose to try to oppose the use of necessary scientific words. On the contrary, the precise use of certain technical terms, carefully defined and internationally understood, is an obvious necessity. We shall be concerned here with the words that stand between the technical terms.

If one examines all those passages in scientific papers that are least in accord with good English style, one finds that there are three main kinds of error, which may be described briefly as those of grammar, grandiloquence and German construction.

It would be absurd to treat the subject of grammar at any length here, since good advice on this subject is so readily available. Grammatical errors in scientific papers sometimes make it impossible to be sure what a sentence is intended to mean. In other cases the mistakes are troublesome only because they distract the reader's attention from the subject under discussion. The words ending in *-ing* (especially *using*) are very frequently misused. One repeatedly finds such statements as this: 'Examining a capillary under the microscope, after staining with carmine, it resembles a homogeneous hyaline tube'. Yet anyone who is intelligent enough to carry out scientific research at a university can easily grasp everything that it is essential to know about the use of present participles and gerunds in fifteen minutes.

The menace of grandiloquence seems to derive from the time when doctors used many Latin words; and indeed these errors are much more common in medical and biological than in chemical and physical writings. It is difficult to account for the fact that an Englishman will write '*vide supra*' when he means 'see above'. It is noticeable that those who use Latin tags most freely do not always know enough of that language to realize that the word 'data' is plural.

Long words derived from Greek or Latin roots are often used for expressing very simple ideas. When a man wants to say that something is visible to the naked eye on merely opening the body-cavity, he tries to make it sound grand by saying, 'this phenomenon can be macroscopically observed upon laparotomy'. Sometimes he uses short words, but chooses an elaborate way of expressing himself. Thus, if he wants to refer to a sheet of metal about 1/100 in. thick, he says that it is 'of thickness $\sim 10^{-2}$ in.'. If his intention is to tell his readers that the longest of the six pairs of chromosomes in a cell is about three times as long as the shortest, he writes, 'the maximum size range of the six pairs as represented by the ratio length of chromosome 1/length of chromosome 6 is about 3/1'.

The grandiloquent writer brings in abstract words where none is required. Instead of writing 'because the surface of the retina is spherical', he substitutes 'because of the sphericity of the retinal surface'. Instead of saying that something is near the nucleus, he says that it 'occupies a juxta-nuclear position'.

Genteelism is allied to grandiloquence. People who think it polite to call a napkin a 'serviette' have their counterparts in science, who cannot soil their mouths with paste or mash but must say 'Brei' instead. Another example is 'sacrificed' for killed. Allied to genteelism is the deliberate use—not just occasionally, but over and over again—of archaic words instead of their exact equivalents in plain modern English (for example, 'save' for except).

Vogue-words have their place in the vocabulary of the grandiloquent; but what may be called negative vogue-words must also be mentioned here—perfectly good words that for an inexplicable reason must not be used. Why must the word 'about' never be used by the grandiloquent? Why must they always say '*circa*', '*ca.*', '*c.*', 'approximately', 'around', 'of the order of', and even '$\sim$'? What is the objection to 'separate'? Why must 'discrete' invariably be substituted? (A case can be made for the occasional use of 'discrete', when special emphasis on complete separation is necessary.) 'After' is another negative vogue-word.

Grandiloquence and related foibles, however, are not the worst enemies of good English. A still more serious and more insidious evil exists.

In ordinary speech or writing it would never enter anyone's head to say 'a tea containing cup'; one would naturally say 'a cup containing tea'. Yet in scientific journals one will find (for example) 'iron containing globules', when what is meant is 'globules containing iron'. It is questionable whether the writers of such phrases have ever asked themselves why they adopt this construction, which is strange to our language and does nothing to improve it. Why do they say 'a hyaluronidase treated area' when they mean an area treated with hyaluronidase? Why place a complex adjectival phrase before the noun, and why omit the clarifying preposition? Why say 'non-formalin containing fixatives' instead of fixatives not containing formalin? Why 'eight micra thick sections' when one means sections 8μ thick? Or why does a man who would never dream of saying 'the Jones associated people' write of 'the nucleolus associated chromatin'?

These, however, are relatively innocuous examples, compared with many that disfigure our scientific journals. 'A methylene blue stained preparation of rabbit ear skin' is bad enough, but not quite so bad as '*Dytiscus* red flight muscle sections' or 'the use of acidified (by HNO_3) or alkalized (by ammonia) solutions of silver'. Even these, however, are not the worst English that it is possible to write, if one is determined to pile up qualifying words other than adjectives in front of the noun they qualify. The limit is perhaps reached by 'adenosine triphosphate activated actomyosin contraction'. (To spare the reader trouble, I may mention that this means the

contraction of actomyosin, activated by adenosine triphosphate.) These are words put together without the slightest attempt at clarity or any consideration for the reader. The phrase is worse than merely illiterate: it is rude.

This piling-up before a noun of words that are not adjectives, but are used adjectivally, is rather a new fashion in English scientific writing. It was seldom seen in Britain a quarter of a century ago. There can be scarcely any doubt about its origin. That many American scientists are of German descent is obvious when one looks at lists of authors in journals published in the United States. The process of piling up adjectival phrases is familiar to everyone who knows the German language. It does not make for clarity. It comes naturally to a German to write 'die einzigen, durch unmittelbare Beobachtung sicher zu ermittelnden Stellen' or 'das von dem Objectiv-system in der der Lichtquelle zugeordneten Ebene entworfene Beugungsspectrum'. Unnecessarily difficult though this construction may seem to an Englishman, yet the German language does at least help us, through the inflection of the words, to follow our path through such passages as these. But when this kind of construction is forced artificially on our much less inflected tongue, and the prepositions are omitted, all pretence of clarity is lost.

The German–American style did not originate with men who had set themselves the high ideal of improving our language as a vehicle for scientific ideas. It was, on the contrary, the product of childhood, introduced by people whose parents had spoken in sentences constructed in their native, German way. It is strange indeed that an Englishman or Scot, accustomed since infancy to a simple syntax, with logical order of words, should copy a German–American imitation of English, just because he happens to be writing in a scientific journal. Our own language, as written by those who know and love it, can scarcely be surpassed for clarity, directness and simplicity.

It is noticeable that scientific books published in the United States are often written in a style that is close to ordinary English (though the American people have their own special words, spellings and phrases). The difference in style between American books on one hand and papers on the other suggests that the publishers correct the style of writing where necessary, while the editors of journals do not. It must be remarked that the German influence is altogether lacking from some American scientific papers, which are models of lucidity and good style. A paper by Michaelis[1] on the reaction of dyes with nucleic acids may be quoted as a particularly fine example.

How can the standard of English in scientific journals be improved? One thinks at once of the obvious works of reference—of Fowler[2], Partridge[3] and Gowers[4]. Quiller-Couch's lecture "On Jargon"[5] is packed with good advice and horrid examples. The teachers of English in our schools could help very much, if they were to study the errors made in scientific papers and base their instruction to science students on their findings. Style, however, is largely dependent on example. Good reading makes good writing. One could almost imagine that some of the contributors to our scientific journals had never read anything but German–American. Yet good examples abound, in books of widely different scope. A trio so diverse as Macaulay, P. G. Wodehouse and Sir Winston Churchill have this in common, that their English is lucid. There is no dearth of good examples to suit every taste.

A strange fact that gives some basis for optimism is this. When an author has finished the scientific part of his paper, he often addresses a note of general information to the reader. At this point he suddenly discloses for the first time that he can write English, for his ideas are clearly expressed. If one wished to translate what he now says into the style adopted in the rest of the paper, one would have to write something like this: 'Some related interest possessing observations by the present writer *et al.* will be the subject of *ca.* $10^{0.3010}$ discrete communications'. The fact that he does not write like that shows that he need not have done so in the body of the paper.

One last, necessary word. The best English writers occasionally use some of the strange constructions mentioned in this article, often to produce a special effect for a particular occasion. They do so, however, only at long intervals. The greater part of their writing is so smooth and fluent that the reader forgets that he is reading and knows only that he is absorbing ideas.

Note. With the exception of the passage in inverted commas in the last paragraph but one, all the examples given in this article are genuine: none was invented by myself or modified to suit my purpose. I am indebted to Prof. A. C. Hardy for a careful criticism of the first draft of this article.

[1] Michaelis, L., *Cold Spring Harb. Symp. Quant. Biol.*, **12**, 131 (1947).
[2] Fowler, H. W., "A Dictionary of Modern English Usage" (Clarendon Press, Oxford, 1937).
[3] Partridge, E., "Usage and Abusage: a Guide to Good English" (Hamish Hamilton, London, 1948).
[4] Gowers, E., "ABC of Plain Words" (H.M. Stationery Office, London, 1951).
[5] Quiller-Couch, A., "On the Art of Writing" (Cambridge University Press, 1925).

IMMUNITY AND DEVELOPMENT

"IMMUNITY and Development" was the subject of a session organized by Section D (Zoology) of the British Association at the Bristol meeting. The section opened with an address from the president of Section D, Prof. F. W. R. Brambell; an account of this address has already appeared in *Nature*[1]. In the four papers which followed, two principal themes were developed. The application of immunological techniques in embryology has led to new findings concerning the differentiation of various organs and tissues; these findings, and the way in which they can be fitted into classical embryology, were discussed. The development within the embryo of the immune response itself was also discussed.

Embryological investigations by means of serological techniques were reviewed in a paper by Mrs. R. M. Clayton, entitled "Differentiation and the Development of Tissue Specificity". Preparations of embryonic or adult organs may be inoculated into a suitable mammal or bird, where their protein or polysaccharide components act as antigens, eliciting the production of antibodies. An antibody produced in this way may then be used as a highly specific reagent in tests to distinguish or locate the corre-

sponding antigen. Tests have been devised in which the untreated antibody is employed *in vivo* or *in vitro*; or the antibody may be labelled with a radioactive tracer or fluorescent dye so that its location can be observed. The results of such tests indicate that adult organisms are composed of a complex mosaic of antigens, with different but overlapping patterns of antigens characterizing each organ.

Immunological analysis has been applied to the development of a variety of species, namely, the mouse, chick, newt, frog, sea urchin and certain insects. Some antigens are found throughout the life of an individual, whereas others arise at definite times and places during development. Transitory antigens are found during development, and new antigens tend to appear at crucial stages of development, such as gastrulation or neurulation. During organogenesis and embryonic induction, characteristic changes take place in the distribution of antigens. The use of labelled antibody permits refined study of the localization of antigens: localization has been observed even at the cellular level. Antibodies have been used to produce alteration from the normal course of development. It has been claimed, but not conclusively demonstrated, that naturally occurring antibodies play a part in differentiation.

In his paper entitled "Zoological Implications of Actively Acquired Tolerance", Prof. P. B. Medawar discussed the new developmental phase of the antibody-producing system, and the corresponding novel type of immune response, which he and his co-workers are investigating. The phenomenon of actively acquired tolerance can be expressed in the following terms: that mammals and birds never develop, or develop only to a limited degree, the power to react immunologically against foreign homologous tissue cells to which they have been exposed sufficiently early in fœtal life. Acquired tolerance may be contrasted with the normal intolerance of mammals and birds to foreign homologous tissue: grafts of tissue from another member of the same species are normally rejected, as a consequence of an immunological reaction on the part of the host against the antigens of the graft. An example of acquired tolerance is the long survival and probable permanence of feather-bearing skin grafts between fowls of differing breeds, the hosts having been rendered tolerant by inoculation of donor tissue cells into the egg.

The fact that an animal is unable to produce antibody against its own tissues may be an example of acquired tolerance. The potentially antibody-producing tissue of an individual, at a stage of development when it is unable to manufacture antibody, is exposed to the antigens of the other tissues. Active tolerance of these antigens may consequently be acquired. Later, when the capacity to manufacture other antibodies develops, the individual is unable to do so against its own antigens. Exceptional antigens, as found for example in the central nervous system, are in fact capable of eliciting an immunity in the individual in which they are themselves found. This can be accounted for by the occurrence of such antigens only in sites normally isolated from the antibody-producing tissue, and therefore unable to provoke tolerance. Other naturally occurring examples of acquired tolerance can be found. A disadvantageous case occurs in man when the cells of a malignant melanoma pass from a mother across the placenta into the fœtus, where they multiply and cause death. The survival of the cells in the offspring can be ascribed to tolerance, since cells of maternal origin do not normally survive in the offspring. Another example of tolerance acquired between individuals is provided by the passage of the *Rh* antigen from females into their rhesus-negative offspring. These females may be rendered tolerant of the rhesus antigen as a consequence. If they afterwards bear a rhesus-positive fœtus, agglutinating antibody is manufactured less readily against the rhesus antigen of the embryo.

A remarkable deduction can be made from experiments in which normal lymph node cells are injected into a mouse bearing a foreign skin graft to which it is tolerant. The cells enter and presumably colonize the lymph nodes of their host; in due course the grafted skin is destroyed. Antigens must therefore be passing at all times from tissues such as the skin into the lymph nodes, whether or not the tissue is treated by its host as foreign.

A subject closely connected with the immunological relationship between mother and fœtus was discussed in the paper of Prof. E. C. Amoroso, "The Endocrine Environment of the Fœtus". Hormonal relationships are found between the maternal organs concerned with pregnancy, between these organs and the fœtus, and between the organs of the fœtus. Uterine changes during pregnancy do not depend solely on stimuli emanating from the fœtus, since many of the normal features of pregnancy can be elicited in the absence of a fœtus. As the ovum moves down the oviduct it comes at first under the influence of the ovarian hormones, which control the state of the oviduct walls. Implantation is also under the control of ovarian hormones, and, via the ovaries, of the pituitary. Delayed implantation, a phenomenon of widespread and varied occurrence among mammals, is controlled jointly by the uterus, ovaries and pituitary. After implantation, the maintenance of pregnancy is dependent on the ovarian hormones; however, some animals (including man) are able to produce the ovarian hormones in organs other than the ovaries, probably in the placenta. It is thought that in certain species the placenta is also able to secrete hormones functionally equivalent to œstrogen and progesterone. The action of the ovarian hormones in maintaining normal pregnancy appears to be on the uterine walls, and not on the fœtus itself; for extra-uterine pregnancy may be maintained in the rabbit after ovariectomy.

Recent progress in the techniques of surgical manipulation of the fœtus has advanced the analysis of endocrine relationships within the fœtus. Decapitation technique has proved particularly helpful in the hands of the French school. The adrenal and thyroid glands of the fœtus appear to be under the control of the fœtal pituitary, as is also the growth-rate. The extent of pituitary control varies between different species. The differentiation of the genital system is under the control of hormones released by the gonadal primordia; the gonads and cranial duct differentiate from discrete primordia in either sex, whereas the urogenital sinus, the accessory ducts and glands, and the intromittent organ develop from neutral primordia. The appearance of 'freemartins' in heterosexual cattle twins is due to the passage of hormones in the blood stream when the circulations of the two individuals are crossed. The conventional explanation is that hormones from the male reach the female, arrest the differentiation of female structures, and stimulate the male components. An alternative explanation is that the female gonad may

itself be affected, and that the masculinization is due to the hormonal influence of the freemartin gonad. The results of surgical removal of the fœtal gonads indicate that the later differentiation of the male reproductive structures is under the control of androgenic secretions from the testis, although the role of œstrogenic secretions from the ovary is less clear. The production of gonadotrophins by the placenta is also thought to influence the development of the fœtal gonads. Striking enlargements of the gonads of the fœtus or new-born have been found in man and in such diverse species as the grey seal, horse, giraffe and elephant.

The subject returned to the detection of antigens during differentiation with a paper entitled "Hereditary Differences between Cells detected by Immunological Means", given by Dr. N. A. Mitchison. Knowledge of cellular heredity and differentiation is more advanced for micro-organisms than for the tissue cells of higher animals. Advances in the genetics of micro-organisms have followed the discovery of unit cell markers, the hereditary properties of which can be investigated; the conclusion may be drawn that unit cell markers are needed for the embryological study of differentiation. Antigens are eligible candidates as such markers. However, the results so far obtained with inter-specific immunization against organs are disappointing. Cross-reactions with the antigens of other organs are invariably found.

In marked contrast with this lack of specificity are the results of auto-immunization, where an animal is immunized against tissue from its own body. Precise immunities against central nervous system, peripheral nerve, uveal tract and testis have been obtained experimentally by the use of Freund's adjuvant. Unfortunately for their usefulness in embryology, these auto-immunizations appear to belong to the category of immunological reactions mediated by cells, and are therefore inaccessible by the standard techniques of serology. However, other types of immunological response appear to belong to the same category, such as transplantation immunity and the delayed reaction in hypersensitivity. Special techniques developed for their investigation may also be applicable to auto-immunization; for example, the transfer of immunologically activated cells into adoptive hosts, or the skin reaction to antigen in immunized animals.

Several points of interest were raised in discussion. The possibility that acquired tolerance might be of use in hybridization was referred to, as was the possibility that a graft in a tolerant host might pick up antigens from the host. The need was mentioned for a repetition of the experiments of Guyer and Smith, which were claimed to show that hereditary changes could be produced by immunological means.

[1] *Nature*, **176**, 441 (1955).

PEACEFUL USES OF ATOMIC ENERGY

RADIOISOTOPES IN CHEMISTRY, TECHNOLOGY AND INDUSTRY

By Dr. HENRY SELIGMAN
Atomic Energy Research Establishment

NOBODY expected great revelations at the Geneva Conference on "The Peaceful Uses of Atomic Energy" on work concerning radioisotopes. Isotope applications, in contrast to some other subjects discussed at Geneva, were always free from any security restrictions, and therefore exchange of knowledge and techniques as well as results was possible in the past. The conferences which dealt exclusively with isotopes technique at Oxford (1951 and 1954) were good examples of such collaboration in this field between many countries. An article referring to biochemical, biological and agricultural uses has appeared already in *Nature* (October 22, p. 765). One part of the plenary session and five full sessions were devoted to isotope uses in chemistry, technology and industry.

The first paper of the plenary session, which dealt with survey papers in the field of technical isotope uses, was by P. C. Aebersold (United States), who discussed the importance of isotopes in technology and industry. His paper gave a very complete survey of all practical industrial uses of isotopes in the United States. The specific uses he mentioned were beta-emitters on phosphor materials for luminescence, and the applications of isotopes for voltage production. He discussed several possibilities of making radioisotope-batteries, like the exposure of a semi-conductor to radiation. He also discussed the use of radiation of fission products, and was hopeful that the sterilization of certain drugs would be not only possible but also economical. The following lecture, by H. Seligman (United Kingdom), described advances during the past two years made in the United Kingdom in industrial isotope techniques. He mentioned the development of an instrument for detecting corrosion of pipes from the outside, a new type of instrument for well logging to find the oil–brine interface, and the possibility of sorting coal from shale. J. Guéron (France) gave examples of recent French development in that field. He discussed the work of finding leaks in underground cables and the measurement of hydrogen content in soils by neutron scattering. The tracing of sand in the Mediterranean was described, and details given on the identification of carbon deposits in boreholes using radioactive methods.

The specialized isotope sessions dealt with the following subjects: (1) general uses, production and handling; (2) reaction mechanisms; (3) activation analysis; (4) research in metallurgy; (5) control and technology; (6) fission product applications.

General Uses, Production and Handling

C. E. Eddy (Australia) and C. Simane (Czechoslovakia) gave a survey describing the uses of isotopes in their countries. S. E. Eaton (United States) gave some examples of isotope uses in industry, such as investigating the mechanism of silver plating, and the study of de-icing of aircraft tyres by using tagged silicones.

The production of isotopes received relatively little space at this Conference. A. F. Rupp (United States)

gave a survey of large-scale isotope production at Oak Ridge, and P. E. Carter and L. C. Myerscough (United Kingdom) gave a paper on the production of beta-ray sources for industrial and clinical uses. K. Samsahl and K. Taugbol (Norway) reported on their recent successful preparation of carrier-free phosphorus by a simple diffusion method. Two other papers dealt with the handling of isotopes.

Reaction Mechanisms

A paper by V. N. Kondratyev (U.S.S.R.) gave examples of work done in the Soviet Union to show the high efficiency of tracer techniques in studying the mechanism of chemical reactions. Kondratyev pointed out that the greatest progress can only be made in this field if the tracer methods are employed together with other more orthodox methods of investigation. He mentioned the investigation of the mechanism of the formation of aldehydes, the isotopic exchange of sulphur between elementary sulphur and organic polysulphides and many others. J. Turkevitch (United States) reported on the use of stable and active isotopes in the study of heterogeneous catalytic reactions. He discussed, for example, his work on the migration of the double bond in an organic system using tritium. Carbon-14 has been used for investigating the Fischer–Tropsch reactions between carbon monoxide and hydrogen with an iron catalyst. A great number of investigations were also mentioned using deuterium as the label. W. G. Brown *et al.* (United States) summarized work on the use of tritium in chemical research. They discussed the isotope effect on reaction-rates and the mechanism of nitrobenzylhalide reactions.

Activation Analysis

Only a few papers were given covering this field. One by V. V. Jakovlev (U.S.S.R.) dealt with the determination of rare earths by neutron activation in graphite, beryllium and germanium. I. P. Alimarin (U.S.S.R.) gave details of the application of radioisotopes in co-precipitation methods, the stability of complex compounds and many other analytical problems. A. A. Smales (United Kingdom) outlined recent advances in radioactivation analysis. One example was the determination of trace impurities without using any radiochemical separations, with a single-channel gamma-spectrometer. Other applications described the determination of elements with much greater accuracy than was possible with orthodox methods.

Metallurgy

G. V. Kurdyumov (U.S.S.R.) dealt in his paper with the investigation of diffusion and atomic interaction in alloys with the aid of radioisotopes. This well-established method of following the behaviour of marked isotopes in alloys has been applied by Kurdyumov for ferrous as well as non-ferrous alloys.

Radioisotopes in Control and Technology

J. L. Putman (United Kingdom) gave some details on the work proceeding in the United Kingdom in his paper on the development of thickness gauges and allied instruments. Technological advances in instrumentation based on the prompt emission of γ-rays after absorption of neutrons have been used in well-logging equipment, and single-channel gamma-response has made the development of corrosion detectors a possibility. C. Crompton (United States) spoke on applications of radiation involving penetration and reflexion. Interesting applications are those of X-rays from K-capture to detect and measure sulphur. Crompton also gave details of the utilization of bremsstrahlung from strontium-90 to measure silt densities in lakes. Another application of bremsstrahlung was described by P. Leveque *et al.* (France). He gave details of such a source used for radiography when very low γ-ray energies are necessary. J. L. Putman and S. Jefferson (United Kingdom) discussed the application of radioisotopes to leakage and hydraulic problems; in both these fields much progress has been made in the United Kingdom. A. M. Samarin (U.S.S.R.) described the study of production processes of steel and iron by the use of radioisotopes. The elimination of phosphorus and sulphur during the production process has been followed and equilibrium studies completed. Solidification phases have also been measured after radioactive indicators have been added to an ingot. A paper by D. B. Grozin (U.S.S.R.) dealt with the by now orthodox methods of metal–wear investigations of oils for motor-car engines. The general feeling was that the metallurgical applications, while not new, are extremely useful; and they are in widespread use in Russian industry.

M. Kato (Japan) gave details of work done in his country dealing mainly with isotopes applied to process and quality control. A paper by U. Been and E. Saeland (Norway) dealt, among other things, with some interesting industrial uses of isotopes in Norway. They showed how isotopes have helped in understanding different factors in the production of cement, and they have determined the amounts of catalyst used during the production process.

Fission Products and their Application

One session was devoted to the application of radiations from fission products, a subject which will be of great importance in the near future. It is no accident that on this topic five of the seven papers came from the United States. That country has until now done most of the research in this field. The next few years should bring much more information on the use of these 'strong' sources, as all countries are making great research efforts in this field. L. C. Anderson *et al.* (United States) dealt with the use of gamma-radiation for chlorination of aromatic compounds. They have proved that for certain chlorinations the use of a powerful gamma-source may well be economical. They gave some details on polymerization products of ethylene. The radiation effects on long-chain polymers were dealt with in a paper by A. Charlesby (United Kingdom), who gave a survey of the developments in that field to date. B. E. Proctor and S. A. Goldblith (United States) gave a well-balanced summary on sterilization of foods. The authors predict "the initiation of commercial processes for irradiation sterilization of some pharmaceuticals, food, tissues and packaging materials in the present decade". L. E. Brownell and J. J. Blumer (United States) think the sterilization of medical supplies by gamma-irradiation promising. H. J. Lomberg and S. E. Gould (United States) found that by irradiation the trichinosis cycle in pork can be interrupted, and they believe that this treatment will also be economical. A paper by E. G. Linder *et al.* (United States) dealt with the conversion of radiation into electrical energy. They conclude that practical power sources can only be achieved economically if

low-energy beta emitters of long half-life can be made available at low cost and in large quantities. When, however, only microwatt applications are needed, the present sources suffice.

Isotopery was exhibited at both the Palais des Nations and the Palais des Expositions. Most isotope exhibits were in the Palais des Nations. The Russians showed quite a number of their industrial applications and equipment made for process control. The United States' effort, although generally more on the reactor side, gave still a complete picture of isotope applications. The French exhibited a few, but original applications. The United Kingdom isotope applications were shown in the Palais des Expositions placed centrally between exhibits of British industry. These applications illustrated very well the progress of the past three or four years.

The Geneva Congress gave a very good cross-section of all isotope work although, owing to the very full agenda, there was far too little time to discuss single problems in detail. The spirit in general was above all expectations. The sponsors must be congratulated on the choice of papers, and the very smooth organization which they achieved in spite of the short time given to them for the arrangement of the Conference. I feel that, in order to get the maximum benefits out of such interesting meetings, it may be better in future to have the isotope conferences separate from those on atomic energy.

THE PAMETRADA RESEARCH STATION

OPEN DAYS FOR ENGINEERS

FIVE years ago the Pametrada Research Station, Wallsend on Tyne, held a series of open days for a whole week to publicize the first five years of its existence (see *Nature*, **165**, 963; 1950). During the first week of last October, the Station was again opened, to show its further progress. This time there were fifty-three separate exhibits in the laboratories, more than half of which had been developed in the period under review, some showing most ingenious applications of science to the solution of engineering problems in this field. The research association came into existence "to carry out research, to improve and develop complete steam and gas turbine installations and to advise member firms on all matters associated with the design and layout of marine turbines and gearing, and to set up standards of fit and finish required in the principal components of turbine machinery". Its name is derived from the initial letters of its full title: The Parsons and Marine Engineering Turbine Research and Development Association. To see the Research Station in action as the visitors did, ten years after its foundation, was to appreciate the courage and faith of its founders in the value of applying science in their industry. The aim of the director, Dr. T. W. F. Brown, then was, and still is, not merely to keep marine engineering in Great Britain abreast of competition, but also to keep it ahead of the rest of the world.

The value of the site, buildings and equipment now exceeds a million pounds, while there is a staff of more than three hundred. Some of the equipment for full-scale trials of marine turbines is the largest of its kind in the world. No such test equipment existed in the early days of the steam turbine, and this may have been one of the causes of its very slow development in the years immediately following the death of Sir Charles Parsons in 1931. To apply scientific methods to the improvement of marine propulsion machinery to-day, it is of immense value to have test equipment large enough to make full-scale trials ashore.

Most of the work at the Station has been done on the steam turbine; but during the past five years considerable effort has been devoted to improving the gas turbine for marine work, and the experimental 3,500-s.h.p. marine gas turbine that was on view five years ago has since been run over a wide range of operating conditions and with different fuels. These have shown that, when residual oil is used (which is necessary in marine work for economic reasons) serious troubles are encountered with fouling and corrosion, unless expensive additives are used.

The most impressive exhibit was the experimental gas-turbine rig, in which the combustion chamber and stator were operating at a gas temperature of 2,200° F. and a mass flow of 5½ lb. per second. The stator was lined with blades of ceramic material, and the demonstration was shown without the turbine rotor so that the distortion of the stator and combustion chamber could be studied with the combustion chamber alight. This rig will later be fitted with a turbine rotor having liquid-cooled blading, each hollow blade containing a mixture of liquid sodium and potassium metal, to transfer heat down the blade axis to the root embedded in the rotor shaft, which is water-cooled. A special technique is required to handle the liquid alloy of sodium–potassium, which is used as the heat transfer medium, because it is so chemically active in the presence of air and moisture. Means for doing this were shown in another exhibit, the so-called 'dry box'—a glass-sided chamber, in which helium is continuously circulated over the specimens. The design is based on that of a similar chamber used at the Atomic Energy Research Establishment, Harwell, for handling radioactive materials. Impurities in the helium atmosphere of the dry box of 1 part in 100,000 can be detected.

Apparatus was on view designed for studying liquid cooling for gas-turbine rotor blades. A single hollow blade with a suitable liquid enclosed in the cavity was carried at the end of a rotating arm, driven by a steam turbine at speeds up to 11,000 r.p.m., heat being supplied electrically to the extremity of the blade and taken away by water flowing over its root. Exhibits on a smaller scale showed studies of refractory materials such as silicon carbide that are suitable for use as nozzles in uncooled furnace linings in high-temperature gas turbines. One of the several tests to which these parts were subjected was repeated thermal shock, the temperature being changed in a matter of seconds from 1,000° F. to 2,200° F., and vice versa, for hundreds of hours.

Research on the steam turbine is at present mainly concerned with the development of a double-casing high-pressure turbine in which the inner barrel exhausts into the annular outer casing, which is therefore subject to exhaust steam pressure and

temperature and so is relatively cool (400° F.), when compared with the inlet temperature (900–1,200° F.). A 4,000-h.p. high-pressure turbine of this type was shown under test. This design is a logical development from a number of successful double-casing low-pressure turbines already in service at sea. Tests have been carried out on a quarter-scale model of this turbine casing to determine the transient distortions of the casing such as may occur during manœuvring and under steady-running conditions. Another exhibit in this section was an instrument that has been developed to enable turbine rotors to be rebalanced in their own bearings on board ship at low speeds. The bearing pedestal vibrations were detected by a relative electromagnetic pick-up activated by a tunable mass–spring system that could be tuned to resonance at the turbine rotor speed, so that vibrations at this frequency were highly magnified. By suitable attachments the vibrational velocity, which is proportional to the out-of-balance resultant force, and the position of this force around the shaft from a reference point were indicated, to provide the information required for rebalancing.

The staff at Pametrada have become famous for their application of electronic techniques to the study of noise and vibration on ships at sea, very largely due to the inspiration and leadership of the late Mr. H. G. Yates, senior designer. Specialist instruments have been designed for this work, including a portable vibration-meter, Muirhead–Pametrada wave analyser, low-frequency wave analyser, automatic wave analyser and electronic torsiograph. The use that has been made of such equipment on board ship has now made it possible for the vibration characteristics of even the most complicated gear and turbine machinery to be predicted in the design stage with a considerable degree of accuracy.

Much attention has been paid to the improvement of transmission machinery, both by the study of toothed gearing of all kinds and by the design and testing of hydraulic reversing transmissions, of which a working model was on view. Six scale models in 'Perspex' showed the space requirements, machinery weights and fuel consumptions for comparable machinery installations of various types designed for a power of 10,000 s.h.p. Present-day requirements of steam turbine, gas turbine and diesel engine were shown by the first three, which could be compared with the others—a high-temperature high-pressure steam turbine set, a high-temperature gas turbine with water-cooled blading, and a steam turbine set supplied with steam from a nuclear reactor.

It was shown that during the past decade the cost and weight of marine turbine and transmission machinery has been reduced by 15 per cent and 50 per cent respectively, while efficiency has been improved 12 per cent. An impressive array of pictures of ships engined by Pametrada designs was on view, the total shaft horse-power of those completed and already in service exceeding 2¼ million. A recent change of policy has led to installations of Pametrada design being built by two licensees in Holland and one in Canada. The hope of those responsible for the exhibition is that owners of ships having seen it may go away and order the most up-to-date machinery embodying the results of this research, instead of being content with conventional designs.

CHEMICAL RESEARCH LABORATORY, TEDDINGTON

OPEN DAYS

THIS year the Chemical Research Laboratory, Teddington, of the Department of Scientific and Industrial Research, held its open days during September 27–30, and again the invitations attracted a large number of visitors from government departments, industry, universities and schools. Some of the outstanding exhibits by the six research groups are briefly described in this article.

A feature in the Corrosion of Metals Group was the illustration of advisory services to industry, public bodies and other inquirers. These services, which constitute an important part of the work of the Group, were depicted in two ways: one gave typical inquiries and replies in summary form, the other showed selected letters and the replies almost in full. The questions and answers dealt with a wide variety of subjects and from diverse sources, such as an interested layman, a county surveyor and a research association. The information supplied is based on general corrosion science and on the knowledge gained either in *ad hoc* investigation or in fundamental researches within the programme of research of the Group.

The results of radioactive tracer studies of corrosion inhibition were illustrated graphically. Potassium chromate containing a proportion of radioactive chromium atoms is used, and the amount of chromium found on a steel surface after immersion in the radioactive solution is estimated from the amount of radiation emitted from the surface. Using this technique, it has been shown that during immersion in chromate the growth of the protective film containing chromic oxide on the surface of the metal obeys the same law as the formation of a surface film of ferric oxide during exposure of steel to air. One exhibit illustrated the work being carried out on the development of tarnish-preventive wrappings for use with copper, silver and their alloys. The access to the metal of hydrogen sulphide (small traces of which in the atmosphere are responsible for tarnishing) is prevented by incorporating in the wrap a substance that absorbs the sulphide or converts it to an innocuous compound, or acts as a barrier. A number of additives have been found effective. They include chlorophyll, certain salts of chromic, nitrous and phosphoric acids, hydroxides of certain metals, and tannins with and without the addition of alkali. The investigation is still at an experimental stage, but the results of laboratory tests have been confirmed by exposure in an outdoor shed, and in a sideboard and over a mantelpiece of a living room. Patent applications have been filed both in Great Britain and abroad, the exploitation of these patents being in the hands of the National Research Development Corporation.

The exhibits on view in the Inorganic Group covered the three main lines being pursued by the Group, namely, the preparation of pure elements, the separation of the rare earths and the search for useful elements in wastes and low-grade materials. The

demand for highly pure elements for semiconductor research has led to a study of methods of purification, and equipment for the zone-refining of bismuth, gallium and tellurium was demonstrated. For the separation of the rare earths, ion-exchange methods are being examined, coupled with the use of the 'complexone' type of reagent. A large plant has been constructed that will handle kilogram quantities of mixed earths. It consists of two banks of eight columns, all interconnected, together with ancillary equipment, and each column has a resin bed about six feet in depth. A laboratory model of the plant was also on view, as well as a small collection of rare-earth minerals. This research also includes the preparation of the pure rare-earth metals; but this has so far been confined to cerium and lanthanum, small ingots of which were shown. The third line of research was illustrated by the search for selenium in waste products and its discovery in sludges collecting in certain parts of the plant for purifying sulphur dioxide produced by the burning of pyrites in flash roasters. Specimens of the various dusts and sludges occurring in the various stages of the purification plant were on view, the selenium content of these varying from a few parts per million to 60 per cent. This source could provide a substantial additional contribution to the limited supplies in Britain. The excellent collection of pure metals stocked by the Pure Metals Committee of the Department of Scientific and Industrial Research was also on view.

A new type of paper chromatography, which makes use of chemically modified cellulose, was exhibited by the Radiochemical Group. By phosphorylation or amination, normal cellulose is converted to cation- or anion-exchange material respectively and from these special forms of cellulose sheets of paper and columns of powder are prepared for the separation of various metal and acid mixtures. Aqueous solutions of simple salts are used as solvents. Field techniques for the determination of trace metals in soils for geochemical prospecting purposes were again on view. The range of metals dealt with has been considerably extended by the use of both chromatographic and colorimetric procedures.

A new ion-exchange process for the recovery of gold from cyanide solution, which takes advantage of the high selectivity for aurocyanide shown by a weak-base dimethylamine-type resin was demonstrated. This resin enables gold to be extracted from a cyanide solution containing other heavy-metal cyanides with almost 100 per cent selectivity. Another ion-exchange exhibit indicated how uranium can be recovered from dilute sulphuric acid solution by adsorption on a strong-base ion-exchange resin. A new development in the use of solvent extraction for the recovery of metals was illustrated by the use of a kerosene solution of acetyl pyrophosphate for the extraction of uranium from an aqueous solution of phosphoric acid. A physical investigation being undertaken uses a quartz spectrograph with a photomultiplier as light detector to study positive-ion plasma oscillations in halogen-quenched Geiger counters.

Among the exhibits shown by the Organic Group was a semi-micro zone-melting apparatus in which 0·15 gm. of compound can be purified. The material under treatment is contained in a glass tube of 2 mm. internal diameter which is moved vertically upwards at a speed of 1 in./hr. A short molten zone is produced by focusing the filtered light from a 100-W. lamp upon the specimen. The removal of 0·05 per cent of induline from naphthalene was demonstrated. A further exhibit was concerned with a new class of compound containing the pentocyanoferrate group (see *Nature*, **176**, 80; 1955). Experiments were shown supporting the structure $[Fe(CN)_5HNC_6H_4OH]^{3-}$ for the ion, obtained by the reaction of $Na_3[Fe(CN)_5NH_3]$ with *p*-aminophenol. Possible applications of the intensely coloured compounds of this series included in the exhibit were as spot reagents for metals and for aromatic amines in paper chromatography, and their use in organic syntheses.

Methods for the determination of the molecular weights and molecular-weight distribution of high polymers are being investigated by the High Polymers Group. Instruments shown included an ultracentrifuge, a micro-diffusion apparatus and a light-scattering photometer. Of particular interest was the ultra-centrifuge, which can be used both for analytical and preparative purposes and in which the sedimentation of polymers in solution can be studied both visually and photographically. Zimm–Myerson type osmometers are being used for demonstrating the behaviour of synthetic membranes of graded permeability which have been prepared during research on the osmotic properties of membranes.

Other exhibits by the High Polymers Group illustrated the preparation and uses of ion-exchange membranes. These exhibits included a model electrodialytic cell of the type which can be used for the desalting of brackish water; the water to be treated is passed continuously through the cell, which contains a series of compartments separated by cation- and anion-exchange membranes arranged alternately. In fundamental studies on ion-exchange equilibria, factors determining the selectivity of ion-exchange resins have been investigated. A simple method for the preparation of paper with ion-exchange properties has recently been devised in which the paper is prepared by incorporating a finely divided ion-exchange resin in a cellulose pulp, and experiments were shown illustrating the use of both cation- and anion-exchange papers of this type in chromatographic separations.

The National Collection of Industrial Bacteria, which this year has supplied more than a thousand cultures to industry and research establishments, demonstrated the various techniques employed: methods of preservation, pure culture isolation, freeze-drying in various suspending fluids, morphological and biochemical tests, methods of assay, etc. There were also striking displays of pigment-producing bacteria and antibiotic-producing organisms.

The Microbiology Group also exhibited a new and unusual cytochrome isolated from the strictly anaerobic sulphate-reducing organism, *Desulphovibrio desulphuricans*; it is notable as the first cytochrome to be observed in an obligate anaerobe, and it acts as the major link between the oxidation of organic carbon compounds and the reduction of sulphate by the cell. A continuous fermentation technique, almost automatic in operation, is being used for the reduction of sulphate to sulphide, with hydrogen gas as the reducing agent and carbon dioxide as the main carbon source for cell growth. The same process is being used in the mass production of sulphate reducers for the extraction of cytochrome. Another demonstration illustrated the production of hydrogen sulphide (and therefore sulphur or sulphuric acid) from raw sewage sludge enriched with sulphate. The hydrogen sulphide is produced at the expense of

methane normally evolved during the anaerobic digestion of sludge; but this drawback is being overcome by the development of methane-producing strains resistant to the inhibitory effect of sulphide. Bacteria concerned in the decay of pyretic fossils, a cause of some perturbation in museums, were also on view.

OBITUARIES

Prof. James B. Sumner

JAMES B. SUMNER, professor of biochemistry at Cornell University, Ithaca, New York, best known as the first to achieve the crystallization of an enzyme, died on August 12 at the age of sixty-seven at Roswell Park, Buffalo, New York. He had been in excellent health up to a few months before his death. He is survived by his wife, three sons, two daughters and seven grandchildren.

The crystallization of urease in 1926 was Prof. Sumner's most important scientific achievement. The history of this work can be read in his own words in "The Story of Urease" (*J. Chem. Education*, **14**, 255; 1937) by anyone who wishes a first-hand, true-to-life account of his prolonged efforts to purify the enzyme and then to defend his idea of its chemical nature against severe and intolerant criticism. His skilful refutation of this criticism required experiments of a highly ingenious and exacting nature.

Prof. Sumner was also well known for his work on the enzyme catalase. Another of his major accomplishments that is, however, not so widely known was the first crystallization of a hæmagglutinin (concanavalin *A*) from jack-bean meal, and the discovery that this protein required the presence of a divalent metal for its action.

Prof. Sumner was an excellent teacher as well as research worker, as the writer can testify from personal experience. He constantly brought his lectures to life by means of a variety of personal anecdotes. He was probably at his best, however, in the less formal teaching of his assistants and graduate students, to whom he communicated his wide knowledge of practical laboratory technique.

In carrying out his own research, Prof. Sumner impressed one as being something of a magician. He would often work furiously without revealing exactly what he expected to discover, and then the rabbit would appear. It should be added, however, that in the case of urease, nine years of persistent work were required before his final objective of isolating the enzyme was attained. His thinking was concrete rather than abstract, and his mind operated by brilliant flashes of intuition rather than by the more laborious process of logical deduction from a given set of premises.

Prof. Sumner was somewhat abrupt in manner, and this was apt to lead people to an attitude of reserve towards him until they found by closer association that his true nature was one of kindness and humanity. He was a very loyal friend. He was free from the intolerable conceit often shown by persons of considerable attainment, although he was justifiably proud of his accomplishments. It is unfortunate that, despite being made a joint recipient of the Nobel Prize in 1946 and being elected to the U.S. National Academy of Sciences, he appeared to retain a certain amount of embitterment from the unjustified criticism to which he had at one time been subjected.

Prof. Sumner lost one arm above the elbow in a hunting accident when he was in preparatory school. This may have been an important factor that spurred him on to success in biochemistry, in the face of discouraging advice. In spite of this handicap, he also became an excellent tennis player, and was fond of outdoor sports such as skiing, sailing and hiking.

Prof. Sumner introduced a new era into biochemistry. He lived to see the fruition of his discoveries and on his deathbed he must have felt the satisfaction, in spite of his great suffering, of knowing that he and his work had already become a recognized and important chapter in the history of biochemistry.

ALEXANDER L. DOUNCE

Mr. Harold Burrows, C.B.E.

HAROLD BURROWS, whose death occurred on September 29, will be greatly missed in the world of medical science. His career was both brilliant and unique. After leaving Marlborough College, he qualified in medicine at St. Bartholomew's Hospital, London, in 1899. He soon distinguished himself as a surgeon and, serving in that capacity in the First World War, was twice mentioned in dispatches. At the conclusion of hostilities he retained his link with the Services by accepting the appointment of consultant surgeon to H.M. Forces with the rank of colonel. In 1919 he was made C.B.E. On resuming his profession after the War he gradually built up one of the largest practices in the west of England, becoming consulting surgeon to both the Welsh Orthopædic and the Gosport War Memorial Hospitals. Harold Burrows received the Jacksonian Prize of the Royal College of Surgeons in 1922 and in the same year was appointed a Hunterian professor. The latter distinction was again conferred upon him in 1933 and 1935.

Shortly after publishing "Pitfalls in Surgery" in 1926, which was an important contribution based largely on his own experiences as a doctor, he became conscious of the strain his large practice had upon his health, and was finally persuaded to abandon clinical work. In 1927 he became a voluntary worker in the research department of the Royal Cancer Hospital, which later became known as the Chester Beatty Research Institute. Burrows was a keen and observant naturalist with a profound biological background, so the transition from medical practice to the life of a laboratory worker was not unduly difficult. In 1930 he was appointed experimental pathologist to the research staff of the Hospital.

Even while engaged in medical practice, Burrows had managed to keep abreast with scientific literature, and his special interest lay in endocrinology and the relationship of hormones to certain forms of cancer. Very naturally this became his special field; but his interests in cancer research covered a very wide range. He published, apart from his several textbooks, more than seventy papers since he gave up practice in 1927. Some of these articles, mainly on experimental carcinogenesis, were published in collaboration with Sir Ernest Kennaway, Sir Charles Dodds and Profs. J. W. Cook, W. V. Mayneord and E. Boyland. Apart from these numerous scientific contributions, his book "Biological Action of the Sex Hormones", published in 1945, was in many ways a classic. With his combined clinical and biological knowledge, few were better qualified than Burrows to write a book on this complex subject.

It was a critical review of the subject and dealt mainly with the physiological activities of the sex hormones and the reactions of normal tissues to them. A second edition was published by the Cambridge University Press in 1949.

After his retirement from the Chester Beatty Research Institute in 1945, he collaborated with E. S. Horning and published "Œstrogens and Neoplasia" in 1952. This book dealt exclusively with the part played by the sex hormones in both the induction and prevention of certain forms of endocrine cancer, and included much of Burrows's own fundamental work. When Lacassagne in 1932 published his fundamental discovery that œstrogens were implicated in the cause of mammary cancer, Burrows was already working on the same problem and was therefore one of the first to confirm Lacassagne's results. Continuing his researches along these lines, he was the first to discover the relationship of œstrogens to the induction of scrotal hernia in rodents, and also to find that œstrogens are not only carcinogenic but also carcinostatic, since they are capable, under certain conditions, of restraining the growth of some forms of hormonal neoplasms.

Burrows was particularly interested in the endocrine factors involved in the causation of tumours of the reproductive organs, and shortly before he died at the age of eighty he had already completed the manuscript for a book on this important subject. His last contribution was published in 1954 in the *Journal of Obstetrics and Gynæcology*.

Harold Burrows's many researches over a wide field of cancer, especially those on the study of disorders of the endocrine glands and their relation to the induction of neoplasia, form a very important contribution to our present-day knowledge of this subject. Many have lost a good colleague; but all can take consolation in the fact that his work has helped to enrich the annals of science.

E. S. Horning

NEWS and VIEWS

The Negative Proton

The University of California and the U.S. Atomic Energy Commission have jointly announced the detection of the negative proton, or 'anti-proton' (cf. *The Times*, October 20). Protons which had been accelerated to an energy of 6,200 MeV. in the bevatron, the proton synchrotron of the University of California Radiation Laboratory at Berkeley, were allowed to collide with a copper target. Negatively-charged particles coming out in a forward direction from this collision were selected and separated in momentum by a focusing and analysing magnet system to provide a beam of negative particles of known momentum. After a time of flight of about one-tenth of a microsecond, this beam may be expected to consist mainly of negative pi- and mu-mesons, with some negative K-mesons (mass about 965 electron masses) and possibly negative protons. These particles were then distinguished both by measurement of their time of flight from the target (since particles of different mass have different velocities for given momentum) and by means of a device measuring the velocity of each particle passing through by the angle of its Čerenkov radiation. In this way the presence of negative particles with protonic mass (within about ten per cent) and distinct from the known K-particles and hyperons was established. Their rate of production for the momentum and direction of this experiment was about one negative proton for every 50,000 negative pi-mesons with the same momentum and direction.

No clear evidence of the existence of the negative proton had previously been available. A very direct interpretation could be given for several isolated cosmic-ray events which have been reported by invoking the negative proton, but these interpretations were not unambiguous. On the other hand, theoretical physicists have always had great difficulty in constructing any relativistic theory of the neutron and proton which did not require the existence of their 'anti-particles', the anti-neutron and the negative proton. The theories which have been proposed suggested that these anti-particles could be created together with a proton or a neutron, a nucleonic pair-creation process, when sufficient energy was available to form the rest mass of the nucleon-antinucleon pair in accord with the Einstein relationship between rest mass and energy. The negative proton would be stable in vacuum, but it was expected to react rapidly on collision with normal nuclear matter, a negative proton and a normal nucleon undergoing mutual annihilation and becoming transformed into lighter mesonic particles. It seems most probable that this annihilation process would generally lead to two or three fast pi-mesons, although there are also other possibilities. It has not been established experimentally yet which are the annihilation processes of importance.

The discovery of the antiproton has removed a major uncertainty in theories of the structure of the basic nuclear particles. It may thus be compared with the discovery in 1932 of the antiparticle to the electron, the positively-charged electron known as the positron, in accordance with the prediction of Dirac's theory of the electron. The importance of the present discovery lies in showing that symmetry between particle and anti-particle, already known to hold for the electron and positron and for the positive and negative pi-mesons, is characteristic also of the heavy nuclear particles, and may therefore be expected to be a general and deep feature of any account of the elementary particles of Nature.

Industrial Fund for the Advancement of Scientific Education in Schools

Some companies which are concerned in the chemical, electrical and mechanical engineering fields of industry, viewing with growing disquiet the shortage of scientists, mathematicians and technologists, have decided to take steps to assist the teaching of pure and applied science and mathematics in secondary schools. The names of the companies are: Associated Electrical Industries, Ltd.; British Insulated Callenders Cables Co., Ltd.; British Petroleum Co., Ltd.; British Portland Cement Manufacturers, Ltd., Group; Courtaulds, Ltd.; The Distillers Co., Ltd.; English Electric Co., Ltd.; Esso Petroleum Co., Ltd.; General Electric Co., Ltd.; Arthur Guinness, Son and Co., Ltd.; Imperial Chemical Industries, Ltd.; Imperial Tobacco (Great

Britain and Ireland) Co., Ltd.; Rolls-Royce, Ltd.; The Shell Petroleum Co., Ltd.; Tube Investments, Ltd.; Vickers, Ltd.; The Wellcome Foundation, Ltd. These companies have accordingly established an Industrial Trust, to be known as the Industrial Fund for the Advancement of Scientific Education in Schools. For capital works at maintained schools, public funds are available, but no such help exists for independent schools and direct grant schools, at many of which the facilities are seriously inadequate through lack of capital resources, and it is therefore to these that the sponsoring companies are directing their intentions. The assistance will be given solely by the provision of capital grants towards the building, expansion, modernizing and equipping of science buildings in independent schools and direct grant schools in the United Kingdom, the Channel Islands and the Isle of Man. More than one and a half million pounds has already been guaranteed; but it is believed that many other companies that depend on adequate supplies of pure and applied scientists and technologists will wish to add their support. Indeed, only shortage of time has prevented their being approached already.

An Executive Committee of the Fund has been formed, consisting of the following: Sir Wilfrid Anson; Mr. R. A. Banks; Sir Hugh Beaver (*chairman*); Mr. E. H. O. Elkington; Dr. Willis Jackson; Mr. W. E. Jenkins; Prof. G. F. Mucklow; Mr. J. A. Oriel; Dr. F. Roffey; Dr. C. P. Snow; Sir Alexander Todd; Lieut.-Gen. Sir Ronald Weeks; Mr. A. H. Wilson. The secretary of the Committee is Mr. Peter Ashton, of Courtaulds, Ltd., and the address of the Fund is 20 Savile Row, London, W.1. It will be the responsibility of this Committee to adjudge and assess all applications; its decisions will take into account both the volume and quality of the existing science teaching in any school, as well as the nature of the proposals put forward to extend and improve it, and the steps which the school has taken to help itself.

Future Policy of the Wellcome Trust

Sir Henry Dale, chairman of the Wellcome Trust, has recently explained the activities of the Trust in relation to the Wellcome Foundation from which its funds are derived, and also the character of its benefactions up to date. The Trust came into existence in 1936 on the death of Sir Henry Wellcome, though the activities of the Foundation and its associated branches commenced much earlier. The first demand on the Trust was the payment of very heavy estate duty, for which Sir Henry Wellcome had made no provision in his will, and for the first five years of its existence all the income of the Trust, which was derived from dividends received on its shares in the Wellcome Foundation, Ltd., was devoted to paying off this duty. Although the Foundation's profits during the Second World War rose considerably, due to the expansion of business in the manufacture of medical and therapeutic supplies, most of the money was either taken as excess profits tax or used in the new capital expenditure demanded by the urgent war-time expansion of its activities. Nevertheless, the Trust has been able to function to a limited extent, the most notable of its benefactions being the endowment of a Wellcome chair of tropical medicine and a Wellcome chair of pharmacology in the University of London. In addition, it has given funds for numerous fellowships and studentships both in Britain and overseas, and has also made provision for an important new medical library for the Royal Society of Medicine, and for three large museum floors, for anatomy and pathology, as a major part of the new building of the Royal College of Surgeons in Lincoln's Inn Fields. Sir Henry Dale pointed out that whereas the activities of the Trust in the past have necessarily tended to be sporadic, the time has now been reached when it can be assured of a substantial income and therefore has the opportunity to initiate a planned policy for spending its resources. To ensure such a longer-term policy and a more co-ordinated planning by the trustees, a full-time administrative staff is needed to deal with the charitable aspect of the Trust's functions, and Dr. F. H. K. Green, formerly principal medical officer on the headquarters' staff of the Medical Research Council, has been appointed scientific secretary of the Trust with the chief responsibility for the executive organization of its spending policy.

Message for the Foreign Ministers at Geneva

On October 21, on the eve of the meeting of Foreign Ministers at Geneva now in progress, a public meeting was held in the Central Hall, Westminster, to give expression to the sense of urgency widely felt that there should be a fruitful outcome of the discussions. The meeting was sponsored by Earl Russell, Lord Boyd Orr and Prof. C. F. Powell, and a message signed by them and Sir Richard Coppock was sent to Geneva. In it they refer to the Geneva meeting as the natural successor of the July meeting of heads of States, and continue: "At this moment, so crucial for the future of man, we should like to bring to the attention of the Foreign Ministers the warning signed by some of the most eminent scientific authorities in different parts of the world, which dealt with the perils of nuclear war. That statement suggested that neither the public nor the governments of the world are adequately aware of the dangers facing the human race. We feel that statement still to be true; and that the Foreign Ministers need to approach their discussions with a deeper awareness of these dangers. The Foreign Ministers, like all of us, have to learn to think in a new way. They have to ask themselves how they can reach specific agreements on the problems before them so that they will rule out any military contest of which the result must be disastrous to all. . . . We wish to impress on them the view that agreements on one problem will improve the possibility of agreement on others; but that disagreement on any one problem should not rule out discussion and negotiation of others. On the question of Germany and European security, it is good that the governments have recognized that these problems are closely linked. There can be no stable peace while Germany remains disunited, but its unification must be brought about in a way which will not involve an important accession of strength to either East or West and will help to end the division of Europe into two hostile blocs. On the question of a disarmament plan involving reduction of conventional arms, the abolition of nuclear weapons and an effective scheme of control, the viewpoints of both sides now seem so close that agreement ought to be possible". Other matters mentioned are further measures for the exchange of visits and information, the easing of trade restrictions as a contribution to world economic stability, and the recognition of the Peking Government. The message concludes: "In making the cold war a nightmare of the past, the Foreign Ministers

will have the support not merely of the peoples of both sides, but of the species Man".

Humane Killing of Animals

The Universities Federation for Animal Welfare has issued a revised edition of its pamphlet, "Kind Killing", dealing with the humane killing of animals (pp. 28; from the Federation, London, 1955; 6*d*.). The booklet is particularly valuable because the author, Dr. Jean Vinter, realizes that in many circumstances the methods advocated may not be practicable. Sodium pento-barbitone, for example, is recommended for killing dogs and cats, but the most humane ways of shooting these animals are also described. Where this cannot be done, the best way of chloroforming is explained, as are the methods to be used in gas poisoning and electrocution. A separate note is included on the disposal of new-born kittens and puppies. Besides mammals, the pamphlet gives some useful hints on the killing of birds, reptiles, amphibians, fish and invertebrates which are nuisances or needed for dissection.

1955 "Science in Industry" Essay Competition

Seventy-seven entries were received for the 1955 "Science in Industry" Essay Competition organized by the *Sunday Times* and *Research*. The *Sunday Times* section of the competition proved to be the more popular, forty-three entries being received for it. The entries were remarkable for their diffuseness, and none was written in a style suitable for a newspaper appealing to the lay public. In consequence, no award was made. The standard of the *Research* section of the competition was a little higher. The first prize (£100) and the Waverley Gold Medal were awarded to Dr. F. Peter Woodford for an essay entitled "Living Reagents"; Dr. Woodford, International Wool Secretariat Postdoctoral Fellow in the University of Leeds, also received the special prize (£50) for the best entry from a competitor less than thirty years of age. The second prize was awarded to Dr. E. C. Potter, a physical chemist employed by the Central Electricity Authority, for an essay entitled "Corrosion in the Modern Power Station". Dr. Potter's essay will be published in *Research*.

University of Birmingham

The following have been appointed to chairs in the University of Birmingham: Dr. D. G. Tucker, formerly senior principal scientific officer at H.M. Underwater Detection Establishment, Portland, to the chair of electrical engineering; and Prof. D. G. Catcheside, professor of genetics in the University of Adelaide (see *Nature*, **168**, 234; 1951), to a chair of microbiology. The title of reader in chemical engineering has been conferred by the University on Dr. S. R. M. Ellis, and that of reader in pathology on Dr. D. B. Brewer. The following have been appointed lecturers: Dr. G. E. Brown (mathematical physics), Dr. G. Bullock (physical metallurgy), Dr. R. F. King (geophysics), J. Manhajm (mechanical engineering), Dr. W. T. W. Potts (zoology) and Dr. S. J. Taylor (mathematics). The following have been appointed to research fellowships: T. R. Carson (electron physics), B. W. Downs (mathematical physics), J. Graham (physical metallurgy), Dr. W. H. Holden (National Coal Board fellowship in chemistry), K. B. Mathur (Imperial Chemical Industries, Ltd., fellowship in chemical engineering), D. S. Rowe (experimental pathology), and Dr. W. I. Stephen (Imperial Chemical Industries, Ltd., fellowship in chemistry).

University of Leeds

The University of Leeds has conferred the title of reader in textile industries on Dr. H. N. Chamberlain, senior lecturer in rayon technology in the Department of Textile Industries. The following have been appointed lecturers in the University: Dr. D. A. Armstrong (Brotherton research lecturer in physical chemistry); Dr. P. Gray (physical chemistry); Dr. B. W. Langley (organic chemistry); R. D. Mackey (civil engineering); and Dr. R. M. Tennent (physics).

University of London

The following appointments have been made in the University of London: C. H. Barnett, senior lecturer at St. Thomas's Hospital Medical School, to the University readership in anatomy tenable at that School; and Dr. R. S. F. Schilling, reader in the Nuffield Department of Occupational Health in the University of Manchester, to the University readership in occupational health tenable at the London School of Hygiene and Tropical Medicine.

Announcements

Sir George Barnes, director of television, B.B.C., since 1950, has been appointed principal of the University College of North Staffordshire, Keele.

Sir Herbert Manzoni, engineer and surveyor of the City of Birmingham, has been elected chairman of the General Council of the British Standards Institution in succession to Mr. John Ryan, who has completed his three-year period of service as chairman. Sir Roger Duncalfe, chairman of British Glues and Chemicals, Ltd., has been re-elected president of the Institution, and Sir Stanley Rawson, vice-chairman of John Brown and Co., Ltd., has been elected chairman of the Institution's Engineering Divisional Council.

The following new appointments at the Brooklyn Botanic Garden, New York, have been announced: Dr. Walter R. Tulecke, formerly of Arizona State College, research associate; Miss Gunny Larsson, of the Arctic Horticultural Research Station at Öjebyn, Sweden, for one year as Ellen Eddy Shaw Fellow; Miss Charlotte Mentges, of Frankfurt, Germany, to the educational staff.

Prof. John Wotiz, assistant professor of chemistry, has been appointed associate professor, and Maak-Sang Tsao, instructor of chemistry, has been appointed assistant professor in the University of Pittsburgh.

Sir Bernard Keen, recently director of the East African Agriculture and Forestry Research Organization, has been appointed scientific advisor to Baird and Tatlock (London), Ltd., 14–17 St. Cross Street, London, E.C.1.

Messrs. Griffin and George, manufacturers of scientific apparatus, announce that, as from November 7, the Griffin and Tatlock Division at Kemble Street, Kingsway, London, will be closed: all correspondence should be addressed to Griffin and George, Ltd., Ealing Road, Alperton, Wembley, Middlesex (Tel.: PERivale 3344. Telegrams: Grifgeorge, Wembley).

Erratum. In the communication entitled "Site of Virus-like Particles in Rous Fowl Sarcoma Cells", by M. A. Epstein, in *Nature* of October 22, on p. 785, col. 2, line 3, the word 'are' should be omitted; it is the vacuoles which are visible by phase-contrast microscopy.

TELEVISION AND FILM UNIT AT THE LONDON ZOO

THE Zoological Society of London, its Gardens at Regent's Park and its Park at Whipsnade have always enjoyed a great deal of newspaper and radio publicity. With the advent of the Independent Television Authority (ITA) several programme-producing companies have been formed, and some of them have asked the Zoological Society of London to grant them television rights. The Society takes the view, however, that it would be wrong to grant exclusive rights to any one company, and that it would be equally impossible to have numerous companies working on the Society's premises, perhaps even at the same time, and disturbing its work. Exclusive rights cannot be granted nor can a completely non-exclusive arrangement be contemplated. The Society has therefore decided to make the best possible zoological material available and at the same time to retain control of the Society's interests in television programmes and films, and to ensure that no responsible organization is denied the opportunity of broadcasting the programmes of its work. This will best fulfil the Society's policy of presenting its work to the public.

Of the several approaches made to the Society, all of which were carefully considered, that made by Granada was by far the most attractive and practicable. Granada proposed that the Society, in conjunction with Granada, should establish a permanent resident Television and Film Unit to produce programmes for television, for the cinema, and for more specific educational and scientific purposes. The Unit will be under the direction of a university-trained zoologist and will have at least two cameramen, perhaps more, preferably people with some scientific interest in zoology. It will cover all the work of the Society at Regent's Park, Whipsnade, on expeditions abroad or wherever it may be necessary to go for special material. Its first function will be to provide the Society with documentary material, and it will be able to undertake long-term projects which may need a considerable period of time for their completion.

The Society looks to television for something more than revenue alone. It is the medium that can best project the Society's work and encourage the primary object of the Society's Royal Charter, granted in 1829, which is "the advancement of Zoology and Animal Physiology and the introduction of new and curious subjects of the Animal Kingdom" on a scale far beyond the possibilities previously available. The work of the Unit will fulfil these objects laid down in the Charter, and while it will not suffer from any lack of scientific integrity it will have a wide appeal to the public. The use of the new medium will do much more than exploit the easy entertainment value of animals; the possibilities for such a Unit are enormous and have never been grasped by any organization before.

In addition to its long-term projects and quarterly schedules of work, the Unit will keep a daily diary in picture and sound of events of special interest, new arrivals and so on, thus building up an extensive film and sound library for use in making programmes, educational and research films. Documentary matter needing the slow accumulation of material over months or even years will be recorded, and zoological expeditions to all parts of the world will also be an important part of the work of the Unit. Techniques to be used will include photomicrography, slow-motion cinematography, infra-red lighting and the 'hidden eye' to observe animal behaviour continuously over long periods.

The films will be available for production of television programmes and also for exhibition in cinemas, universities and schools. In addition, live broadcasts will be regularly produced. Granada will in general have first option; but the television programmes will be available to other users. Granada will distribute the programmes and films.

Under this arrangement the B.B.C., with which the Society has co-operated fully for many years, will be able to broadcast programmes of zoological interest in association with the new Unit.

SMOKE ABATEMENT IN BRITAIN

CONFERENCE IN BOURNEMOUTH

THE National Smoke Abatement Society may take credit for having provided for many years a platform on which discussion of the problems of smoke abatement have been given full scope. All elements of the community have in their turn been given their say. From year to year there have been heard the oft-repeated claims of the crusaders for cleaner air. For quite a few years careful research work and surveys of atmospheric pollution have been carried out by the Atmospheric Pollution Research Committee, and a conference of representatives of local authorities has been held under the ægis of the Department of Scientific and Industrial Research. One must not forget, too, the contributions to technical development, which have a bearing on these problems, made by a large body of scientists and engineers in fuel technology and resulting in a knowledge of how to burn fuel smokelessly. The Society's platform has again in these fields been the means of publicizing from time to time the painstaking efforts in technical development that must provide the basis of any really effective action in smoke abatement.

In this critical year of the Society's history, the Government's Clean Air Bill is likely to be debated. Accordingly, the proceedings of this year's annual conference of the Society, held in Bournemouth during September 28–30, are of particular interest. In keeping with past traditions, all aspects of the thorny problems to be faced have in some measure received attention, and opinions have been voiced which ought to reach the ears of the legislators. In his presidential address to the Society, Sir Ernest Smith rightly stressed the influence, in bringing about this situation, of the informed body of opinion into

which there have been injected a large variety of ideas and much practical understanding by the activities of the Society. This is not to disregard the contributions made by that other large but silent body of expert opinion containing the practitioners of the technologies involved, who for upwards of a generation have provided a technical basis upon which smokeless combustion practice may be achieved. Without the 'know how' to burn fuel smokelessly, legislative action would be ineffective. The need at the present time is the problem of effective application of this existing knowledge.

The conference this year has provided interesting descriptions of recent progress in domestic heating by centralized methods, in particular of the Westminster City Council's district-heating scheme, considered from the financial, engineering and operational aspects. The scheme shows a saving of coal as well as an overall economy, a reduction of atmospheric pollution and improvement in domestic amenities.

Floor warming was an ancient practice known to communities as wide apart as the early Koreans and the Romans. To-day, with the application of electrical heating, the principle of thermal storage may be applied, the electricity being supplied to concrete flooring in 'off-peak' periods. Gradually, but surely, the hardy and reluctant dwellers of the British Isles are succumbing to the lure of the use of partial central heating, an interesting new feature of this practice being the application of forced circulation of hot water in small pipes—a result of research by the British Coal Utilization Research Association. All the heat from the boiler is kept within the living space of the house and is localized mainly in the radiators as the piping is so small. Another interesting article explains how the stuffiness of ducted hot air, another practice emanating from the Romans, may be safeguarded by suitable control of the movement of the air. The above are merely a selection of the many interesting points emerging from the technical discussions of the conference.

On the issues involved in the projected Clean Air Bill, opinions were many and comprehensive, ranging from contributions by the representatives of local authorities to several informative explanations of the purport of the Beaver Report by members of the Committee. These make much more intelligible reading than does the draft of the Clean Air Bill itself. Proverbially, the draft of a Parliamentary Bill in any case provides a form of mental persecution for the layman. The contributions to the Bournemouth conference give at least a clear indication of the intentions of the Report, and the reactions of much representative opinion from the local authorities. The views of the ordinary man and of the industrialist were unfortunately not heard; this is to be regretted, since they may be regarded in some respects as the victims for the sacrifice.

The objectives of the conference were, as would be expected, altruistic and worthy. The factors of practicability of some of the intentions may be quite another matter, about which, it is to be hoped, something may at last be heard in the debates in Parliament, if the victims have not become mesmerized by the certainty of a kill. Nevertheless, it must be agreed that now there looms before us some prospect of wise action which may contribute materially to a cleaner Britain that is so much desired by all. How much cause for thanksgiving may emerge in next year's conference.

R. J. Sarjant

CAMBRIDGE ASTRONOMICAL SYMPOSIUM

THE symposium on "Astronomical Seeing", held at the Observatories, University of Cambridge, during September 12–14, was timed to follow the General Assembly of the International Astronomical Union at Dublin, and thus to take advantage of the presence in Europe at this time of astronomers from all over the world. Its object was to provide a forum for the exchange of ideas and information relating to the various aspects of the subject. These aspects include the accumulated knowledge of visual observers; the extensive *ad hoc* instrumental studies that have been made more recently, especially in the United States; the theory of scintillation, developed mainly with particular reference to radio problems; and meteorological information about inhomogeneity and turbulence in the atmosphere. The aim was to provide time in the programme for sufficient discussion, so that progress could be made towards the resolution of real differences.

Dr. J. S. Hall (U.S. Naval Observatory, Washington, D.C.) described experiments in which correlations had been found between intensity scintillation in certain frequency-ranges and the speed of the upper winds. Lamps attached to balloons showed less scintillation even at a height of 30,000 ft. than did stars observed at the same time; but it is probably unsafe, he said, to conclude from the experiments so far made that appreciable seeing effects come from greater heights. Dr. Hall showed a film of shadow bands crossing the objective of the Washington 40-in. telescope, and of extra-focal Hartmann patterns. Dr. P. B. Fellgett (Cambridge Observatories) reviewed the physical theory of scintillation. Plane wavefronts of starlight are diffracted by irregularities in the refractive index of the air, and the diffracted beams interfere to give phase- or amplitude-scintillation according to their mutual phases, which depend on the distance from the irregularities. Brightness-scintillation is usually negligible just below the irregularities, and increases with distance, while phase scintillation decreases slightly. The complex autocorrelation function of the amplitude across the mean direction of travel remains constant; and the mean intensity distribution in a telescopic image is also independent of distance from the source of disturbance. The spatial frequencies in the scintillation differ in general from those in the irregularities of refractive index. Dr. A. Hewish (Cavendish Laboratory) presented quantitative results for some chosen cases. He showed calculations and slides of the detailed development of brightness changes beyond sinusoidal phase-changing layers of various amplitudes; of the interchange between brightness changes and phase-scintillation; and of the corresponding autocorrelation functions of complex amplitude, showing the dominance of harmonics of the layer-frequency when the phase change is large. The corresponding statistical developments were shown for a layer having a Gaussian autocorrelation function of refractive index.

Dr. G. Keller (Perkins Observatory, Ohio) gave a detailed account of work at the Perkins Observatory. Observations have been made of the temporal power-spectra of brightness changes for various telescope apertures; the correlation of scintillation in certain frequency-ranges with upper-wind speed; correlation of upper-wind direction with the dependence of

scintillation, observed through a slit covering the objective, on the position-angle of the slit; and the degree of coherence between scintillation in selected frequency-ranges observed in two neighbouring apertures. Dr. W. H. Steavenson (Cambridge) discussed the effects which can be distinguished visually in extrafocal images or when the eye is placed at the focus of the telescope. The 'high seeing' appears as shadow patterns blown at high speed across the aperture, and defocusing experiments indicate an average height of origin of about 10 km. Slower shadow bands originating within a few hundred feet of the telescope can be seen to move with the surface wind. Local dome and tube effects are recognizable by their geometry. In large reflectors, the cooling of the mirror causes disturbances in the thin layer of air at the face of the mirror; these are much more serious than the well-known changes in mirror asphericity and can often be the dominant cause of image spread. Dr. A. Hynek (Ohio State University, Columbus) reported studies of image motion made by Dr. A. G. Wilson at Flagstaff, Arizona. Star-trails recorded on fast-moving film showed the amount of movement, the proportion of the time that the image is sharp, and the occurrence of multiple images. These studies were made with special reference to the design of methods of photographing Mars, and an important conclusion is that at Flagstaff the instantaneous image movement is nearly the same over the whole disk of the planet. Dr. Hynek also reported some very recent work at Ohio State University which included measures of image movement in two colours. If image-spread were an effect of rapid image motion, this might provide a further test of the remark of Hewish and Keller that the red images may be expected sometimes to have a sharper 'core' than the blue.

Dr. B. H. Briggs (Cavendish Laboratory), describing radio observations of the scintillation at neighbouring wave-lengths, said that in the ray-interference approximation the correlation across the spectrum is simply related to the spread in the ray path-lengths between the source and observer. Rapid frequency-change experiments yield records similar to the spectrum-scintillation photographs of Zwicky, and the problems of interpretation are also similar. Dr. E. H. Linfoot (Cambridge Observatories) took up the question of measuring the harm done by bad seeing. Seeing effects reduce the rate at which a given telescope can record information about the sky. The loss can be estimated in terms of the mean transmission factors (sine-wave response factors), which are essentially equal to the mean autocorrelation function of the complex displacement across the aperture. Dr. Linfoot showed how the reduction in information capacity (in Shannon's sense) can be calculated from the statistics of seeing; generally speaking, the loss is of second order when the phase-errors are small. Dr. R. Goody (Imperial College of Science and Technology, London) presented meteorological data on turbulence and convection in the atmosphere. By day, in clear weather, convection is most intense near the ground and falls rapidly throughout the first 1,000 ft. Convection is enhanced over large mountains and islands. A small island should have good daytime seeing, and even a few feet of height above the ground could be beneficial. Aircraft results show inhomogeneities at various heights. A few accelerometer records from balloon flights show increased turbulence near the tropopause, but it is not known whether this is typical. The northern edge of the jet stream in the northern hemisphere is sometimes very turbulent. Generally, however, the atmosphere is non-adiabatic and is continually being mixed, so that the causes of seeing effects are unlikely to be confined to any narrow range of height.

In the discussion, widely different opinions were expressed about the usefulness of the ray approximation to the Huyghens wave treatment. One view is that ray theory is adequate under suitable conditions for small phase perturbations. It was urged in reply that ray theory is essentially the limit of wave theory as the wave-length becomes very small compared with the relevant geometrical path-differences, so that it is expected to be valid (as in aberration calculations) only for large phase-changes. It was the general opinion that the phase-changes corresponding to good seeing could be of the order of a few radians, but the lack of any specific measurements of this fundamental quantity illustrates how much is still to be learnt. It was pointed out that the combined effect of spatial smoothing by the objective aperture, and temporal smoothing in the electrical filters, would in general make the amount of scintillation recorded photoelectrically dependent on the transverse speed of the shadow bands. Until this is allowed for, it cannot be said whether the observed wind-scintillation correlation represents an actual physical connexion between wind-speed and optical inhomogeneities in the air. Non-isotropic inhomogeneities would necessarily give rise to telescopic images that are not radially symmetrical, although this effect might be masked by disturbances originating at another height. It was suggested that the height of origin of scintillation could be found in principle from the cross-over wave-length in the colour scintillation; from the ratio of phase to brightness-scintillation at different wave-lengths; and by the analogue of the spaced-receiver experiments of Briggs *et al.*, the linear transverse velocity being found from the correlation of scintillation in two apertures and the angular velocity by observations of two neighbouring stars. A plea was made for observations in narrower wave-length ranges.

HUNGARIAN–CZECHOSLOVAK POLAROGRAPHIC CONFERENCE

FOR the first Hungarian–Czechoslovak Polarographic Conference held in Veszprém, Hungary, during August 11–14, seventeen Czechoslovak polarographists, mostly from the Polarographic Institute of the Czechoslovak Academy of Science, were guests of the modern Chemical University in Veszprém at the meeting arranged jointly by the University, the Hungarian Chemical Society and the Hungarian Academy of Science. Prof. J. Heyrovský was the leader of the Czechoslovak delegation; from the Hungarian side, Dr. Polinszky (dean), Dr. Preissich (secretary of the Chemical Society), Dr. Cieleszky (chairman of its Polarographic Section), and Prof. Bognár (general secretary of the Hungarian Academy) organized the Conference extremely successfully. The Minister of Education, Prof. Erdey-Grúz, a prominent physico-chemist, was in the chair. At the opening of the Congress, a diploma of honorary fellowship of the Hungarian Academy of Science was presented to Prof. J. Heyrovský, who then delivered an address on the "New Trends in Polarography". Prof. L.

Erdey addressed the general assembly on the "Development of Polarography in Hungary".

The forty-six communications that followed were divided into two parallel sections, one for applications in inorganic analysis, the other for biochemistry and biology. Lectures and discussions were in German, English, French, Hungarian and Slovak. General oscillographic polarography was discussed at a conjoint meeting by J. Heyrovský and quantitative oscillography by R. Kalvoda, who demonstrated their specially constructed cathode-ray oscillographs. As innovations may be mentioned: polarographic estimations of chromatograms (J. Proszt and J. Kis), automatic polarographic analysers of long duration (J. V. A. Novák), streaming of electrolytes induced by alternating currents (J. Dévay), derivative currents obtained by electromagnetic induction (J. Proszt and J. Paulik), deposition of magnesium at the streaming electrode (K. Győrbiró, L. Poós and J. Proszt). In the biological section, several communications concerned Brdička's protein test, the determinations of vitamins, oxygen in tissues, alkaloids and many applications in pharmacy and food production, and the study of macromolecules by means of suppression of maxima.

The communications will be published in full in German by the Hungarian Academy of Science in a special volume. Brief abstracts of the papers may be obtained through Dr. E. Bodor, Chemical University, Veszprém, Hungary.

It should be added that Veszprém lies close to the famous Lake Balaton, on the banks of which the delegates enjoyed discussions for several days after the Congress.

J. Heyrovský

NATIONAL PHYSICAL LABORATORY, TEDDINGTON

REPORT FOR 1954

THE annual report for 1954 of the National Physical Laboratory, Teddington*, consists of the report of the Executive Committee which was presented to the General Board at its meeting during the afternoon of May 20, 1955, the annual open day of the Laboratory (see *Nature*, 175, 1102; 1955), and detailed reports, prepared by the respective superintendents, of the work of the nine divisions and Test House of the Laboratory.

The Executive Committee refers with particular pleasure to the visits of Their Majesties the King and Queen of Sweden on June 29, and of the members of the Royal Commission on the Civil Service on May 12. Other visitors during the year included parties from the Royal Naval College, Greenwich, and delegates from the joint spring meeting of the Institute of Metals with the Société Française de Metallurgie, and from the General Assembly of the Internationl Union of Pure and Applied Physics. A thirty-minute television outside-broadcast directly from the Laboratory took place on June 2, and the work of the Laboratory, with special reference to aerodynamics research, was also described in a schools' broadcast on October 27. In addition, the director of the Laboratory, Sir Edward Bullard, took the leading part in a studio programme, entitled "Power from the Sun", which was broadcast on October 11.

* Department of Scientific and Industrial Research. National Physical Laboratory: Report for the Year 1954. Pp. viii+98+7 plates. (London: H.M.S.O., 1955.) 4s. net.

At the beginning of the annual report, the names of the members of the General Board, the Executive Committee, the Promotions Sub-Committee, the Froude Ship-Research Sub-Committee, and a newly constituted body, the N.P.L. Advisory Committee on Radioactive Standards, are listed. The new Committee formerly existed as an informal body, consisting of representatives of the Atomic Energy Research Establishment, the Radiotherapeutic Research Unit of the Medical Research Council, the Royal Cancer Hospital and the National Physical Laboratory; Dr. B. W. Robinson, superintendent of the Physics Division of the Laboratory, was appointed chairman of the Committee. In order to make the work of the Laboratory better known to industry, two liaison officers were appointed during the year for a three-year period, and it is reported that they have visited thirty-two research associations and have made direct contact with a number of industrial firms. The new building for the Metallurgy Division, which contains the refractories section, the X-ray section and laboratories for work on radioactive tracers, was formally opened by Sir Lawrence Bragg on April 6, and in June a new Division, that of Control Mechanisms and Electronics, was formed by amalgamating the control mechanisms section of the Metrology Division with the Electronics Division. The field of work to be covered by the new Division is a wide and important one, dealing with the automatic control of experimental, industrial and administrative operations and the development techniques and equipment for data-processing and computation; but, at present, work is to be restricted to a continuation of that previously carried out by the two original sections.

The Laboratory took part in several exhibitions of scientific apparatus, including the Physical Society annual exhibition, the Royal Society soirées and a conversazione arranged by the Institution of Civil Engineers. Two international symposia were held during the year at the Laboratory, one in May on "Creep and Fracture of Metals at High Temperatures" and the other in November on "Precision Electrical Measurements". The proceedings of the symposium on "Automatic Digital Computers", held in March 1953, and four new booklets, Nos. 5–8, in the series "Notes on Applied Science" were published during the year. In addition, one hundred and forty-six scientific papers were contributed by members of the staff of the Laboratory to various journals and periodicals; lists of these are appended to each detailed divisional report.

The individual reports of the various divisions of the Laboratory indicate the wide range of scientific subjects covered. The Laboratory has, in addition to an extensive research programme, part of which is paid for by other government departments, certain specific responsibilities, including the maintenance of standards and routine test work. It would appear that the programme contains more items than are really desirable, and a reduction in the number in order to enable more rapid progress to be made with the remainder, and perhaps also to commence on a few new urgent items specially appropriate to the Laboratory, is being considered. The Aerodynamics Division has carried out important work on the application of boundary-layer control to the reduction of drag and the increase of lift. Helicopters appeared on the research programme of the Division for the first time, and a twin-rotor model for wind-tunnel tests was being made. Some fundamental work con-

sisting of high-speed tunnel experiments on the flow of air at supersonic speeds over elliptic cones has already received practical application in the behaviour of high-speed aircraft and the use of highly swept wings.

In the Control Mechanisms and Electronics Division work has continued on digital computers, analogue computers and data-reduction devices. Two magnetic-drum stores have been installed on the pilot model of the automatic computing engine (ACE); an enlarged and improved version of the electronic simulator has been put into service and used in conjunction with the London School of Economics for an extensive study of economic systems: and, at the request of the Committee on High-speed Computers of the Department of Scientific and Industrial Research, a group was formed in May to study the mechanization of large-scale clerical operations by means of electronic-digital techniques and equipment. A new impulse generator for 3·2 MV. was installed during the year in the high-voltage section of the Electricity Division, and, in connexion with its work on frequency standards, a highly stable oscillator controlled in frequency by a cavity resonator has been developed by the Division. Steady progress was maintained with the cæsium atomic-beam standard.

The Light Division has spent several years developing methods for the production of diffraction gratings using techniques suggested by Sir Thomas Merton. The stage has now been reached where good-quality and reasonably sized gratings, suitable for use in research and industry, can be produced comparatively cheaply. Work on the application to the control of machine tools of the system of moiré fringes which is formed when two identical diffraction gratings are superimposed with their rulings nearly parallel has also been actively pursued. The Metrology Division reports considerable progress in the development of autocollimation and pneumatic gauging as a means of making highly accurate dimensional measurements for research and industry, and mention is made of the machines that have been built in the Laboratory to measure bore diameters of 0·1–6 in. to an accuracy of ± 0·000 01 in., in addition to an apparatus to measure the diameter of wire as fine as 0·000 2 in. to a similar accuracy. A new absolute determination of gravity, in which the free up–down motion *in vacuo* will be timed, is envisaged, in order to improve the accuracy of measurement of barometric pressure and hence the steam point, and some preliminary work has already been done on the proposed interferometric method for measuring the distance over which the motion is to be observed. Consideration is also being given to the construction of a transportable primary-standard barometer for additional improvement of the precision of realization of the temperature 100° C.

In the Metallurgy Division an investigation of the processes taking place during the fatigue of metals has been started, and in the study of intercrystalline fracture of ion alloys and certain copper alloys at low temperatures some remarkable results have been obtained. A comprehensive report was issued in October 1954 giving results of creep tests lasting up to ten thousand hours (more than a year) on steels to be used in the British Electricity Authority's new power stations. The Physics Division has co-operated in an international comparison of three resistance thermometers, constructed at the United States National Bureau of Standards, Washington, D.C., the Institute of Metrology, Leningrad, and the National Physical Laboratory, respectively, and its acoustics and sound measurement section has given assistance with a form of acoustical treatment designed by the Building Research Station for the stonework of the new Coventry Cathedral. The radiology section has constructed a new free-air ionization chamber for use with X-rays generated up to 300 keV. Features of the new chamber are that it is of the guarded-field type and that the air pressure and the potential of the case relative to that of the electrode system can be varied. The Mathematics Division has devoted most of its time to the solution of problems for industry and other government departments, using the pilot model of the automatic computing engine, and one of the largest problems tackled has been the analysis of stresses set up in the steam-catapult retardation structure in H.M.S. *Ark Royal*. An interesting development reported by the Ship Division is that tests were undertaken for the first time during the year on sailing yachts. Considerable assistance in other connexions has also been given by this Division to the Yacht Research Council.

Finally, the annual report, which is presented with an attractive cover and is illustrated, concludes with a report of the Test House and with a list of the senior staff of the Laboratory, arranged according to the various Divisions.

EDUCATION IN ENGLAND AND WALES DURING 1954

THE report of the Ministry of Education on "Education in 1954"* gives statistics for primary and secondary education in England and Wales and for university awards and further education during the year; but the section on advanced technological education in technical colleges continues to display the confusion in which technological education still lies and which the institution of a new award recently announced by the Minister does nothing to remove. The number of children in the maintained schools increased by about 120,000 in 1954 and will continue to grow, but by decreasing amounts, until 1958. The number of children in the infant schools had already started to decline by the beginning of 1954; but the secondary schools will not receive their largest increase in numbers until 1958, and the peak will be reached at the end of 1960. The provision of additional places in secondary schools is well in hand: of some 210,000 new places brought into use during the year ended October 1, 1954, 75,000 were in secondary schools, while a further 200,000 places were under construction; and the building programme for 1954–55 is providing some 120,000 places in secondary schools out of a total of 187,000.

The number of teachers increased by 6,100 in 1953, and for 1954 the increase is estimated as more than seven thousand, while the entry of 11,768 students for two- or three-year courses at training colleges was the highest recorded. Generally, the staffing position tended to improve during the year; by 1961 at latest, nearly all primary-school classes should be reduced to the regulation size of forty pupils or less, and in the secondary schools over the

* Education in 1954: being the Report of the Ministry of Education and the Statistics of Public Education for England and Wales. Pp. viii+197. (Cmd. 9521.) (London: H.M.S.O., 1955.) 7*s.* 6*d.* net.

same period it should be possible to maintain the present staffing standards, which are appreciably better than those of five years ago. The supply of graduate teachers of mathematics and science has continued to cause serious concern, quality rather than quantity being the deficiency in 1954; but difficulty is anticipated in recruiting even a sufficient number of these teachers to meet the growing needs of the secondary schools. Sir David Eccles, in his introduction to the report, refers to the action he has taken to see whether existing salary scales for such teachers engaged in more responsible or advanced work are adequate for their purpose and likely to lead to the needs of the schools being properly met, and also to the consultations with the universities, industry and other departments as to the possibility of restraint in the recruitment of graduate scientists. This approach has been deprecated by the Advisory Council on Scientific Policy in its subsequent report, but no other proposals are made for meeting the shortage, although area training organizations and colleges have considered the possibility of increasing the output of non-graduate teachers able to take some part in teaching science and mathematics, especially in secondary modern schools. The main difficulty has proved to be one of suitable candidates. The National Advisory Council on Education for Industry and Commerce was asked to examine the requirement for trained technical teachers, and on its advice the Minister decided to retain the technical training colleges in Bolton, Huddersfield and London.

The National Advisory Council submitted revised proposals for a national award in advanced technology and has also paid particular attention to the development of sandwich courses, which it discussed with the Federation of British Industries. Although during the year another 113 advanced courses at technical colleges were approved for the special 75 per cent grant (making a total of 493) and the number of advanced short courses for scientific workers and technologists already employed in industry was practically doubled, it is clear that the confusion between technical and technological education persists; and that the proposal to develop ultimately some thirty technical colleges into advanced regional colleges carries grave risks of spreading available resources too thinly to be effective even if staff of the requisite calibre can be attracted. Building projects to the value of more than £7·5 million were completed during 1954 at further education establishments, out of a total £58,858,000 completed. The Minister announced at the end of the year an increase for 1955–56 of £2·5 million in the annual building programme for technical education, as well as the relaxation of certain restrictions on the type of course for which new technical college building can be approved. At the same time, he emphasized the need for continued economy in educational expenditure and for giving priority to certain selected projects if the new advances are to be made good and delay avoided in proceeding to further advances.

More than fourteen thousand students entered universities and university colleges in 1954 with financial assistance from public funds, and further progress is reported towards more uniform practice among local education authorities in standards of selection and in rates of grants. Thirty State scholarships were again offered for mature students, and, since these arrangements were instituted in 1947, 204 such scholarships have been awarded, mostly in English, economics and politics, but in recent years increasingly in natural sciences and mathematics. Referring to Colonial students, the report states that in 1954 the training colleges accepted 161 students from twenty different Colonial Territories and also found places for four students from the Sudan and twelve from Iraq and for seventeen Colombo Plan scholars. There is ample evidence that the experiment of training Colonial teachers in training colleges in Great Britain is proving a success: the students are well liked and hard working, and seem to enjoy the life and work of the colleges. Exchanges of teachers with Commonwealth countries and the United States only totalled eighty-eight (eighty-six in 1953), and only eleven went to European countries (nine to France, one to Germany and one to Austria).

The report also covers the Victoria and Albert Museum and the Science Museum, London, noting that completion by 1960–61 of the Centre Block of the Science Museum building will have accomplished the second of the three stages of development recommended by the Bell Committee in 1912. Issues in the Reading Room of the Science Library were 26,002, compared with 25,241 in 1953; requisitions for external loans rose from 94,772 to 101,683, and 176,960 photocopy sheets were issued compared with 157,894 in 1953. On the major issue of a science centre and the project for a national lending library of science and technology, the report is silent.

ELECTRON MICROSCOPIC OBSERVATIONS ON THE STRUCTURE OF THE SIEVE PLATES IN *CUCURBITA*

By C. E. L. HEPTON, Prof. R. D. PRESTON, F.R.S., and G. W. RIPLEY
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THE movement of solutes through the phloem of plant stems has long been an object of intense study and has produced a voluminous literature. In spite of this, however, it cannot be claimed that any of the proposed mechanisms of transport are any more satisfactory now than they were when first suggested. The explanation is not far to seek. It is generally agreed that translocation occurs along the sieve tubes at rates which are enormously higher than could possibly obtain by diffusion alone. Whether these rates are achieved by convection (for example, mass flow) or by some kind of 'activated' diffusion (for example, movement at an interface) the major barrier to flow occurs in the sieve plate, and it has become very clear that further advances must await a thorough elucidation of the structure of this plate

Fig. 1. Longitudinal section through sieve plate of young *Cucurbita* stem. Shadowed palladium-gold; magnification 18,700 ×. Note the two pores on either flank cut in almost median section; the position of a third pore, out of section, may be detected in the centre

and, in particular, the nature of the content of the sieve pores. This has been emphasized in a recent discussion of the structure of phloem in terms of its functions[1].

We have now completed a series of preliminary observations on the sieve plates of *Cucurbita* which we consider to represent a distinct advance of sufficient importance to be recorded at this time. Pieces of stem 4–5 in. long cut from young plants growing in a greenhouse were immersed for two hours in 0·3 *M* sucrose. This treatment was intended to reduce the turgor pressure in the sieve tube elements and hence to minimize slime plug formation, following the method of Currier, Esau and Cheadle[1]. Separate vascular bundles were then dissected from a central piece about 1 cm. long and fixed in a 1 per cent solution of osmic acid in a veronal-acetate buffer at *p*H 7·25. After washing in buffer solution for two hours they were imbedded in the usual way in a mixture of 10 parts butyl and 3 parts methyl methacrylate. Ultra-thin sections, both transverse and longitudinal, were cut on a Hodge-type microtome made in this laboratory. The methacrylate was removed by passing the sections through amyl alcohol and amyl acetate and the preparations shadowed with palladium-gold. These sections are all of sieve tubes which we presume to be functional.

The transverse sections of sieve plates are not presented since they are not of a quality to yield any new information. They do, however, substantiate as

Fig. 2. As in Fig. 1, magnification 30,000 ×. Note the finely granular appearance of the contents of the pore

fully as such sections can the diagrammatic representations made by Esau[2], namely, that the pores appear to be plugged with material confluent with what appears to be the cytoplasm of the sieve tubes. Representational longitudinal sections, however, which were much more successful and are in any event more likely to yield critical information, are illustrated in Figs. 1 and 2.

Examination of these photographs leads to several important conclusions:

(1) The cytoplasm is continuous from one sieve tube to the next through the sieve pores. The contents of the pores are withdrawn from the pore walls; but this is probably an artefact induced largely by the pretreatment with the sugar solution. It would seem that in Nature the pores are completely plugged. This at last confirms the suspicion voiced by various workers (for example, Crafts[3]) based on much less adequate observation under the light microscope.

(2) There is no continuity of vacuole across the sieve pores. Although the cytoplasmic strands have collapsed, this can scarcely have been due to collapse of a hollow tube, for in that case we would have expected to observe the vacuole opening out on each side of the pore into that of each of the contiguous elements.

(3) The wall of the sieve plate has itself an unexpectedly complex structure. We do not wish at the moment to comment further upon this.

(4) There appear to be few or no micro pores through the walls as large as 200–300 A. as postulated by Crafts[3] in a recent review. The shrinkage of the cytoplasm in the pores makes it difficult to assess the probable condition in untreated material, so that the size of any presumptive micro pores here remains an open question.

Space will not permit a complete analysis of these findings in terms of translocation mechanisms even if this would be profitable at this time. It may, however, be pointed out that even this preliminary work may reasonably be interpreted as demanding a new approach to the problem. The mass flow hypothesis of Münch[4] postulates a continuity of vacuoles from sieve element to element as part of the flow path. This is now demonstrably erroneous, and, in view of the fact that mass flow of the whole cytoplasm is difficult to conceive, the complete hypothesis as first formulated must fall. The attempts made by Crafts[3] to meet this eventuality, by assuming the existence of capillaries in the cytoplasm of the pores of the order of 200–300 A. wide, seems to be on no safer ground even if such pores could be shown adequate to cope with the solute movement. In any event, a simple calculation shows that, even assuming Poiseuille flow in such fine capillaries, the pressure gradient across the thickness of the sieve plate would need to be so high as to be inconceivable.

Similarly, the intervention of cytoplasmic streaming championed by Curtis[5] can scarcely be considered any longer feasible even on anatomical grounds alone. For unless the cytoplasm streams through the pores —demanding a complex and carefully regulated two-way flow which seems highly unlikely—the rate of movement would then be limited by diffusion through the pores. Most workers seem, moreover, to doubt that streaming occurs in mature functioning sieve tubes. Finally, the diffusion at an interface discussed by Van den Honert[6] meets with the difficulty that the only continuous interface available is a solid-liquid interface. Movement at such interfaces is known to be much too slow to account for the measured rates of solute transfer.

It could therefore be that the time has come to discard mechanisms which are fundamentally purely physical. A recent paper by Kursanov[7] emphasizes the probable role of metabolic factors in solute transport in phloem; we can only add that the apparent continuity of the cytoplasm suggests strongly that vital processes play a more important part than is sometimes assumed.

[1] Currier, H. B., Esau, K., and Cheadle, V. I., *Amer. J. Bot.*, **42**, 68 (1955).

[2] Esau, K., "Plant Anatomy" (John Wiley and Sons, 1953).

[3] Crafts, A. S., *Farad. Soc. Disc.*, No. 3, 153 (1948); *Bot. Rev.*, 17, 203 (1951).

[4] Münch, E., "Die Stoffbewegungen in der Pflanze" (1930). See also Crafts, ref. 3, p. 234.

[5] Curtis, O. F., "The Translocation of Solutes in Plants" (1935). Curtis, O. F., and Clark, D. G., "Introduction to Plant Physiology".

[6] Van den Honert, T. H., *Proc. Kon. Akad. Wet. Amsterdam*, **35**, 1104 (1932).

[7] Kursanov, A. L., *Botanicheski Zhurnal*, **37**, 585 (1952) (in Russian).

SPECIFICITY IN CHEMICAL AND ENZYMATIC OXIDATIONS OF GLUCOSE ANOMERS

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THE chemical oxidations of glucose[1,2] and methyl glucosides[2] to gluconic acid are often more rapid with the β- than with the α-anomers. The reagent most extensively studied is bromine in solutions buffered at about *p*H 5·4[4]. Under these conditions, the pyranose ring is converted first to δ-gluconolactone in high yield. Gluconic acid is then formed by slow hydrolysis of the lactone. The ratio of the rates of oxidation at 0° is $\beta : \alpha = 39{\cdot}2$, and similar increased reactivities are found for the β-forms of a number of pentoses, hexoses and disaccharides[2].

Elucidation of the mechanism of these reactions should have an important bearing on the biochemical oxidations of glucose, for which an even higher order of specificity exists. In one such enzymatic oxidation, using notatin (glucose aerodehydrogenase), it was shown that, like the chemical reaction with bromine, the initial product is δ-gluconolactone; further, the reaction is more rapid with β-glucose[5]. It has now been demonstrated unequivocally that the specific substrate of notatin is β-D-glucopyranose[6]; α-D-glucose is oxidized at about the rate of other sugars and the ratio of rates in this case is the highest yet observed ($\beta : \alpha = 156$). An analogous case is that of the glucose dehydrogenase isolated from ox liver, which is also specific for β-D-glucose[7]. Glucose

6-phosphate dehydrogenase similarly produces 6-phosphogluconolactone from the Robison ester[8]; the synthesis of this ester by catalytic saponification of 1 : 2 : 3 : 4 - tetraacetyl - β - D - glucose 6 - phosphate[9] strongly suggests that in this case, too, the enzyme is specific for the β-anomer.

In this communication, an attempt will be made to interpret these chemical and enzymatic specificities in terms of a conformational analysis similar to that developed in the case of *cyclo*hexane and other alicyclic compounds. Such an analysis indicates that the hydroxyl group on carbon atom 1 of α-glucose is in a sterically hindered position, and that reactions directly implicating the hydroxyl group will take place more readily with β-glucose. Mechanisms for the chemical and biochemical oxidations will be discussed in the light of stereochemical considerations.

Conformation of Glucose

Although the possibility of strainless 'chair' and 'boat' forms of the pyranose ring was recognized by Haworth[10], glucose is usually represented in the Haworth perspective formula as a (strained) planar structure, the substituents being considered as above or below the plane of the ring. In 1947, Hassel and Ottar[11] discussed the structure of molecules containing *cyclo*hexane or pyranose rings and stated that: "All experimental evidence indicates that the six-membered pyranose ring found in many sugars will generally have the staggered form corresponding to the symmetrical *cyclo*hexano ring", that is, to the 'chair' form. The possible conformations for pyranoses were considered in detail by Reeves[12], who concluded that in the case of D-glucose the most stable conformation was that indicated as C1 in Fig. 1. The alternative 1C structure (which is derived from C1 by ring conversion[13]) contains more 'instability factors'. Hassel and Ottar further pointed out that if the pyranoses existed in such 'chair' forms, the substituents would occupy either the axial (*a*) or equatorial (*e*) position as in the case of the *cyclo*hexane derivatives (in this communication, the recently recommended nomenclature of Barton *et al.* will be used[14]).

These considerations have been borne out in detail by X-ray analysis of the crystal and molecular structure of α-D-glucose[15]. The pyranose ring is found to be six-membered in the 'chair' conformation and with the predicted *cis*-glycol grouping on carbon atoms 1 and 2. Although this proof of the 'chair' conformation (C1) is conclusive only for the solid state, this most stable conformation almost certainly persists in solution, as the work of Reeves indicates[12]. More accurate representations for the glucose anomers therefore are the formulæ (I) and (II) for α- and β-glucose respectively (Fig. 2). In α-glucose, the hydroxyl on carbon atom 1

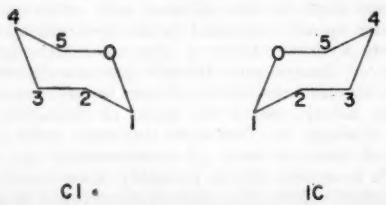


Fig. 1. Chair conformations of the pyranose ring. (These conformations have been redrawn from those of Reeves (ref. 12) so that the position of the oxygen atom in C1 corresponds with that in the conventional Haworth formulæ

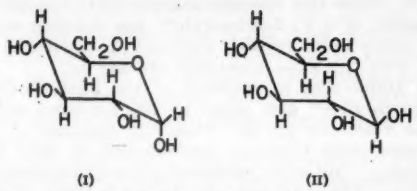


Fig. 2. Conformations of α-glucose (I) and β-glucose (II)

is in an axial position, all the other hydroxyls and the primary alcohol group being equatorial. In β-glucose, all the hydroxyls and the primary alcohol group are equatorial. Differences in the infra-red spectra of α- and β-anomers have recently been observed and related to the fact that the hydrogen atom in the α-anomer is in the equatorial position[16].

Reactivity of Axial and Equatorial Groups in Glucose

It was pointed out by Barton[17] that, because of their more crowded nature, axial groups in alicyclic compounds would tend to be hindered in their chemical reactions. (Examples of compounds sterically hindered in this way have been summarized recently by Klyne[18].) By analogy, therefore, the axial hydroxyl group at carbon atom 1 in α-glucose would be expected to be less reactive than the corresponding equatorial hydroxyl group in β-glucose. This greater reactivity of β-glucose should also extend to compounds in which the hydroxyl group is substituted. There is, indeed, much evidence to show that derivatives of β-glucose are the more reactive, and the following examples are cited in support of this contention.

(*a*) Acid hydrolysis of β-methyl-D-glucopyranoside is almost twice as rapid as that of the α-glucoside[19]. For most glycosides a similar increased rate of hydrolysis of the β-anomers is observed (for examples, see Pigman and Goepp[20]). A notable exception to this generalization is the case of the methyl-D-gulopyranosides, where the α-anomer is more readily hydrolysed. A possible explanation is the anticipated[13] conformational instability of the C1 structure for D-gulose; in the 1C alternative, the α-hydroxyl on carbon atom 1 would be equatorial.

(*b*) The reductive cleavage of β-benzyl-D-glucopyranoside tetraacetate to 2 : 3 : 4 : 6-tetraacetyl-β-D-glucopyranose takes place rapidly and smoothly in dry ether with a palladium catalyst[21]. The corresponding α-derivative is cleaved with difficulty and only incompletely. Similarly with the benzyl-D-xylopyranoside triacetates, the reaction is more rapid with the β-anomer. Since D-xylopyranose has the C1 conformation, this is comparable to the case of D-glucose. With benzyl-D-arabinopyranoside triacetates, the reverse ratio ($\alpha > \beta$) was observed. This is in harmony with the postulated 1C conformation for D-arabinose[13], where the α-hydroxyl would be equatorial. Unfortunately, comparable data for the α- and β-benzyl-L-arabinopyranoside triacetates (where the conformation is C1 and where the cleavage of the β-compound should be the more rapid) were not recorded.

(*c*) Only phenyl-β-glucoside reacts with aqueous alkali to form 1 : 6-anhydroglucose; after two weeks boiling of the α-form with 2·6 *N* potassium hydroxide, there was no rotational change, and 85 per cent of the starting material was recovered in crystalline

form[22]. Since this reaction is believed to require the formation of a 1 : 2-anhydride[23], the reaction would take place more readily with the di-equatorial (β) than with the axial-equatorial anomer (α).

(*d*) Differences in stability of the pentaacetyl-D-glucopyranoses[24] also point to the hindered nature of the α-acetoxy group. Thus the reaction of the β-anomer with titanium tetrachloride is very fast, producing (initially) tetraacetyl-β-D-glucopyranosyl chloride. The α-anomer, on the other hand, is very stable under these conditions.

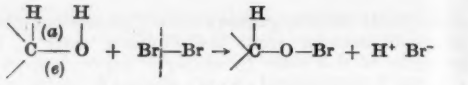
Mechanism of Chemical Oxidation of β-Glucose with Bromine

Although, therefore, in the reactions of the type —OH → —O*R* or —O*R* → —OH, *cyclo*hexane and glucopyranose compounds react most readily when the reagent attacks an equatorial substituent, an apparent exception to this generalization exists in some oxidations of the type =CHOH → =CO. Barton pointed out[17] that the oxidation of some *cyclo*hexanols (to *cyclo*hexanones) with chromic acid in acetic acid solution takes place more readily at an axial than at an equatorial group ; similar differences occur with N-bromosuccinimide in the steroid field. This exception to the general rule that equatorial groups react the more readily was resolved by Barton's suggestion[17] that in these oxidations the rate-determining step was still an attack on an equatorial substituent, that is, on hydrogen. In other words, the rate-determining step did not involve the hindered axial hydroxyl group. This suggestion has received elegant confirmation from the studies of chromic acid oxidations by Westheimer *et al.*[25]. These studies show that the mechanism of such chromic acid oxidations does involve attack on the hydrogen atom as the rate-determining step.

It is apparent that for a given reaction with a pair of anomers the ratio of rates will be determined by two factors : (*a*) the actual reaction mechanism will determine which of the substituents is subject to the rate-determining attack ; (*b*) the overall reaction will be the more rapid when the substituent subject to the rate-determining attack is equatorial.

Turning now to the case of glucose oxidation by bromine, it is suggested that the reaction mechanism of this oxidation involves, as a rate-determining step, a direct reaction at the hydroxyl group. This seems most likely in view of the electrophilic nature of bromine. Since the hydroxyl at carbon atom 1 in β-D-glucose is equatorial, this group should therefore be more reactive in such a reaction than the corresponding (axial) hydroxyl of α-glucose.

Although in the reactions of sugars and halogens it is usually difficult to specify the precise nature of the substrate or oxidant, it has been shown that in the bromine reaction (which with β-glucose is rapid even at 0° and gives almost theoretical yields of the lactone) free bromine is the actual oxidant[3]. Isbell and Pigman suggested that the oxidation took place through an addition product between the ring oxygen atom and bromine[3]. Only in β-glucose was further reaction possible because of the favourable steric situation. Whether or not this addition occurs, it is now suggested that the electrophilic reagent (bromine) will make an initial attack on the equatorial hydroxyl group leading to the hypobromite intermediate (III). If this is the rate-determining step, the rate should be diminished by acid, in harmony with the observed facts.

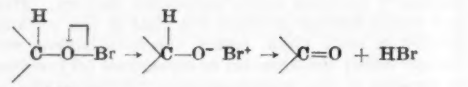


(III)

Considerable evidence substantiating a hypobromite intermediate such as (III) is found in the known reactions of the simple aliphatic hypohalites. Primary and secondary hypohalites are very unstable, particularly to light[26] ; although it has more recently been stated that, in the complete absence of traces of acid, ethyl hypochlorite is stable for several hours[27]. On spontaneous decomposition, primary hypohalites yield aldehydes, secondary hypohalites yield ketones, and the more stable tertiary hypohalites yield a ketone and an alkyl chloride according to the following equations[26] :

$$R\mathrm{CH_2OCl} \rightarrow R\mathrm{CHO} + \mathrm{HCl}$$
$$R_2\mathrm{CHOCl} \rightarrow R_2\mathrm{CO} + \mathrm{HCl}$$
$$R_3\mathrm{COCl} \rightarrow R_2\mathrm{CO} + R\mathrm{Cl}$$

Similar studies led to the conclusion that secondary hypohalites are the least stable[26]. Although alkyl hypobromites are less well known, methyl and ethyl hypobromites can be prepared, at least in solution[28]. It seems reasonable, therefore, to postulate (III) as an intermediate and to make the further assumption that it decomposes rapidly to form the =CO group of the lactone in the same way as do the secondary hypohalites. Since oxygen is more electronegative than bromine, the reaction is written as below ; that is, as a transfer of a hydride ion to a brominium ion. Such a transfer is very similar to that proposed by Hammett for the mechanism of the Cannizzaro reaction[29].



(III)

In one case a slightly increased reactivity of α-glucose to an oxidizing agent, chlorous acid, has been observed[21]. This reaction is certainly more complicated than that with bromine, as indicated by the approximate stoichiometric relationship :

$$R\mathrm{CHO} + 3\mathrm{HClO_2} \rightarrow R\mathrm{COOH} + \mathrm{HCl} + 2\mathrm{ClO_2} + \mathrm{H_2O}$$

Additionally, some cleavage of the carbon chain occurs with formation of oxalic acid. Owing to unfavourable experimental conditions, it was not possible to prove or disprove whether δ-gluconolactone was an intermediate product. It is tentatively suggested that, in this chlorous acid oxidation, the molecular species involved is the free aldehyde (or aldehyde hydrate) form of glucose. Although the results of Jeanes and Isbell[21] are insufficient for precise kinetic calculations, it can be estimated that for the initial period the ratio of oxidation-rates (α : β) is about 2. This is of the same order as the observed ratio of rates of mutarotation ($k_\alpha : k_\beta = 1{\cdot}883$)[3], a process which probably does involve the free aldehyde form. The slightly more rapid oxidation of α-glucose is therefore a result of the more rapid opening of the ring which occurs with this anomer.

Marked differences of rates in favour of β-glucose occur in the oxidation with sodium hypoiodite in alkaline solution[1b] (β : α = 25). It is believed that similar considerations to those outlined above in connexion with the bromine oxidation will also apply in this case.

Mechanism of Enzymatic Oxidation of β-Glucose

It was originally concluded by Bentley and Neuberger[5] that the initial step in the notatin reaction was removal from glucopyranose either of a proton and an electron, or alternatively a hydride ion. In the absence of definite information, these reactions were written so that the hydrogen atom removed first was that attached to carbon. If the arguments developed here are correct, it will be more likely that the initial point of attack by the enzyme is the equatorial hydroxyl group. It is suggested that this attack is developed through an electrophilic site on the enzyme surface (indicated as *X* in Fig. 3), leading to the removal of a proton and the formation of an enzyme-substrate intermediate (IV). This intermediate is analogous to that (III) postulated in the bromine oxidation. The final steps are now very much the same as those originally suggested, that is, transfer of a hydride ion from the intermediate (IV) either directly to the prosthetic group, flavin adenine dinucleotide (FAD), or possibly first to some other reactive site on the enzyme surface. The overall result is thus the transfer of the proton removed initially and the hydride ion to flavin adenine dinucleotide. Although this has been discussed in terms of an ionic mechanism, as originally pointed out[5] it could equally well be represented as a radical mechanism. The only essential difference between the mechanism now proposed and that originally suggested is that the initial point of attack is now believed to be the equatorial hydroxyl group.

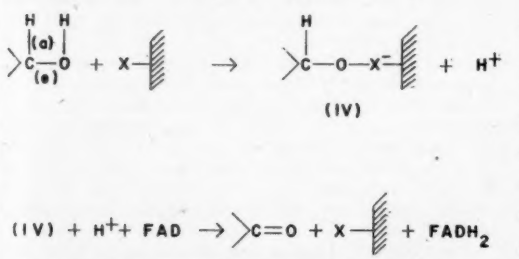


Fig. 3. Mechanism of oxidation of β-glucose with notatin. (*X* is a postulated electrophilic site on the surface of the enzyme)

The biochemical oxidation =CHOH → =CO has also been extensively studied in the inositol series, both with bacterial suspensions (*Acetobacter suboxydans*, *Aerobacter aerogenes*[22,23]) and with cell-free enzyme preparations[23]. The specific stereochemical requirements for these oxidations are that the group being oxidized must be an axial group, and that the carbon atom *meta* to this group must carry an equatorial hydroxyl. These oxidation mechanisms, therefore, are different from those operating in the case of glucose, but closely resemble the chromic acid oxidations discussed earlier; it seems most probable that they involve attack by the enzyme on the equatorial carbon–hydrogen bond as the rate-determining step. Mechanisms analogous to that proposed for the chemical oxidations[25] can readily be envisaged for these enzymatic reactions.

Conclusion

The observed differences in the rates of oxidation of the glucose anomers are believed to be explained on the basis that: (*a*) the reaction mechanism necessitates a rate-determining attack on a hydroxyl group; and (*b*) that in α-D-glucose the axial hydroxyl is sterically hindered.

It seems likely that similar principles will be helpful in many other branches of carbohydrate chemistry and in the interpretation of some aspects of enzyme specificity. It is perhaps significant that an enzyme (mutarotase) which catalyses the interconversion of α- and β-glucose has recently been described in some notatin preparations[34] and in animal tissues[35].

[March 21

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LETTERS TO THE EDITORS

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Experiments on the Complete Suppression of Stammering

We have been conducting simple physical experiments upon people severely handicapped by various forms of stammering or stuttering, and have obtained results of surprising generality. Under certain conditions of external control, these people may be induced to speak fluently at normal speeds, and with no difficulty. The experiments clearly illustrate the fact that stammering (at least of all the varied classes examined) is caused, not by motor, but by perceptual faults.

The twenty-five volunteer subjects (all adult) of this preliminary series were introduced through speech-therapy clinics and exhibited various degrees of speech difficulty. In several cases tonic spasms up to a minute in duration were observed. In all cases, speaking was interrupted by hesitations, repetitions or silent periods. Various objective measures of the degree of speech difficulty have been adopted (for example, time to read a standard text; number of speech breakdowns; sum of durations of the gaps, hesitations and repetitions in utterance). These objective measures enabled us to estimate the improvement during external control.

External control has been exercised by interfering with the complex of monitoring and control processes associated with speaking. Two methods have been employed. In the first, a very loud tone was applied through headphones to the ears of the subject, preventing his perception of the voice sounds which he produced. A frequency of about 150 cycles per second was found most effective. The subject was required to read aloud from a simple text of about 120 words; the results are illustrated by Fig. 1. In this figure, (*a*) shows the duration of repetitions, hesitations and gaps in the speech of these subjects, summed over the period of the test, before the tone is applied; (*b*) shows the same observations when the tone was applied. In both cases, the results have been presented in sequence of subjects, rearranged along the horizontal axis in order of their usual degree of speech difficulty.

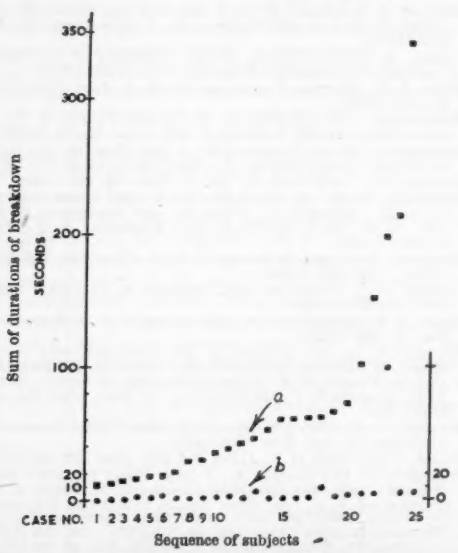

Fig. 1. Total duration of all hesitations, repetitions and silent intervals in the speech of stammerers reading a 120-word test: (*a*) usual performance; (*b*) with applied tone

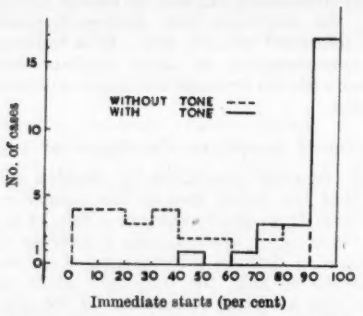

Fig. 2. Histogram showing distribution of cases according to ability to make immediate starts in utterance, both without and with applied tone

In twenty-four cases out of twenty-five, the improvement was remarkable. The exception was the only individual who normally worked in surroundings with a high ambient noise-level.

We also measured the ability of each subject to make an immediate start in utterance, each time a new starting point was indicated, by pointing to a new part of the text. Successive points were indicated randomly and in rapid sequence. We found that when the tone was applied, hesitation was markedly reduced in every case (Fig. 2).

Since aural voice-feedback for speech monitoring is mediated mainly through air and bone conduction, it seemed of interest to verify their relative influences on stammering. Blocking the air-conduction pathway only (as by stopping the ears) did not consistently alter the speech habits of stammerers; on the other hand, if both pathways were blocked (as we have shown with the above technique) stammering virtually ceases.

The second method of interference with the monitoring processes does not involve reading. The subject 'shadows' an unseen message read by the operator steadily and continuously. 'Shadowing' means repeating concurrently. In this situation, the subject did not see the text, and was obliged to concentrate on the message. It is known that such 'shadowing' presents no difficulty to people of normal speech habits[1]. It now seems that stammerers also find little difficulty and can be induced to 'shadow' fluently when reassured, even without practice.

Both normally fluent speech and stammering are believed to be habit-forming for the speaker, and on this basis the shadowing technique has been used by one of us as a form of clinical treatment for stammering. The patients were taught to copy intonation and rhythm while 'shadowing', and to work at steadily increasing speeds.

In five severe cases of stammering, this method has produced a striking improvement in a period of

two to four weeks; this improvement has been maintained in all cases to date; no negative results have so far been obtained.

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Aug. 26.

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The Four Possible Waves in Ionized Gas in a Magnetic Field

According to the magneto-ionic theory of Appleton[1] and others, two distinct radio waves may be propagated through ionized gas permeated by a magnetic field. More recently, three hydromagnetic waves have been found for the same medium[2,3]. A 'plasma' or electron sound wave has long been known, but only investigated for the relatively simple cases of zero magnetic field[4,5] or propagation across the magnetic field[6]. Finally, sound waves must be capable of propagation in the magneto-ionic medium. These numerous waves have been discovered from diverse approaches, and the connexion between them, if any, is not clear.

All waves in the magneto-ionic medium comprise electromagnetic fields associated with oscillations of the electrons and heavy ions. They should all be disclosed by solving the field equations together with suitable momentum transfer equations. The resulting dispersion equation for fully ionized gas is found to be of the fourth degree, indicating four, and only four, possible waves. In more complex gas mixtures other modes appear, but these may be regarded as oscillations of the ion gas within the neutral gas, together with forced oscillations of the latter. Other additional waves which seem to exist when drift motions are present[7] are not real[8], but may result from motion of the observer relative to any irregularities fixed in the gas. Since only four different wave types occur, some of the waves mentioned above must be identical.

At 'low' frequencies (where heavy-ion motion is important) the 'ordinary' and 'extraordinary' hydromagnetic waves have been found and discussed[3]. Their magnetic and electric vectors are elliptically polarized, tending to circular and plane for propagation along or perpendicular to the steady magnetic field. As the frequency rises, these waves retain their identity, although the refractive index of the medium is not necessarily always a real quantity. At 'high' frequencies (when heavy-ion motion is unimportant) they have, as simple limiting cases, the radio ordinary and extraordinary waves of Appleton's theory.

A third wave may occur at low frequencies which we call the 'magnetic-sound' wave. It is almost plane polarized, with the gas velocity vector lying between the wave normal and the magnetic field. A limiting case is a nearly pure sound wave along the magnetic field; its field is an electric potential only. As would be expected, the magnetic-sound wave is not disclosed when gas pressure is neglected (as by Aström[3]).

The fourth wave is important at high frequencies; it is analogous to the magnetic-sound wave and might be termed a 'magnetic-plasma' wave. Like the magnetic-sound wave, it has a simple limiting case in the well-known plasma waves propagated along the magnetic field[5]. The general case of the magnetic-plasma wave (like the magnetic-sound wave) is far more complicated than the special case. It has a full electromagnetic field and a Poynting flux. It does not appear in the usual magneto-ionic theory because electron gas pressure is neglected, an approximation which usually has a small effect on the ordinary and extraordinary waves but annihilates the magnetic-plasma wave.

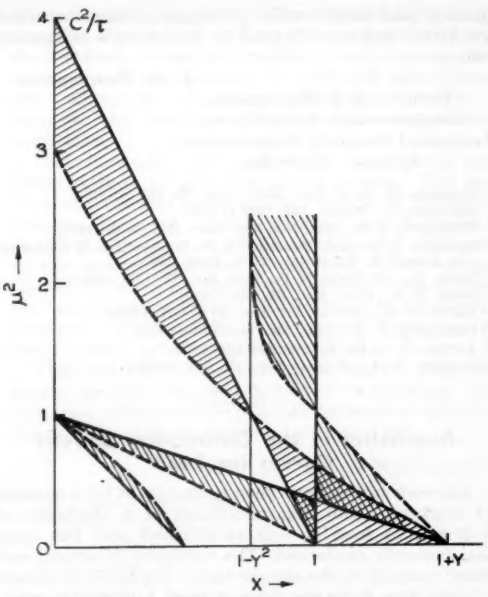

Fig. 1. Refractive indices of the ordinary, extraordinary and magnetic-plasma waves. Ordinary and extraordinary waves, ■; magnetic plasma waves, ▩

Further study of magnetic-plasma waves is important, particularly in regard to the part they may play in the origin of intense solar radio emission. The microscopic approach used by Gross[6] leads to excessive mathematical difficulties in the general case, as well as some very surprising results in the special case he investigated. The use of transport equations may introduce some inaccuracies but permits a general survey of the wave properties to be made with relative ease. A preliminary investigation has been completed.

Vital properties of the ordinary and extraordinary radio waves were demonstrated graphically by Ratcliffe[10], whose plot is shown in Fig. 1. Here μ is the refractive index of the medium and X and Y the ratios of the 'plasma' frequency and gyro-frequency to the wave-frequency; c is the velocity of light and τ is one-third the mean square random velocity of electrons. Full and dashed lines correspond to propagation along and across the magnetic field; the cross-hatched areas between correspond to the full range of oblique propagation. The graph allows wave velocities and reflexion points (in a variable medium) to be estimated. The corresponding plot for the magnetic-plasma wave is shown and seen to overlap that of both ordinary and extraordinary waves. Thus, under suitable conditions the ordinary (or extraordinary) and magnetic-plasma waves having the same fre-

quency and direction of propagation have identical velocities and so will tend to travel as a composite wave.

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Commonwealth Scientific and
Industrial Research Organization,
Sydney. June 23.

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Anomalies in the Cosmic-Ray Shower Curves for Lead

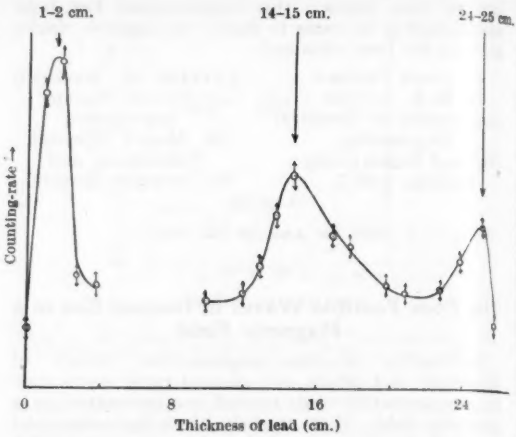
Shower curves have been investigated by a number of workers. The first maximum at a thickness of 1–2 cm. of lead is well established and has been satisfactorily explained. The existence of second and third maxima in the shower curve at greater thickness of lead has, however, been a matter of controversy.

Clay and Scheen[1] have found a second maximum in gold, mercury and lead; they used three-fold coincidences. Its appearance with four- and five-fold coincidences was, however, not equally well pronounced in their experiments. Clay and Klein[2] have confirmed the existence of the second maximum in tin as well, using three-fold coincidences. They, however, do not find any trace of the third maximum, as observed by Swan and Ramsey[3]. Nielsen, Morgan and Morgan[4], using four- and five-fold coincidences, give no convincing proof of the existence of the second maximum.

The second maximum has been explained by Clay and Scheen by assuming that a cosmic ray meson produces a high-energy knock-on electron in lead and the two particles account for three-fold coincidences. A four-fold coincidence will only occur if another electron is produced in the absorbing material either by a knock-on electron, by cascade processes or by the primary meson itself. They believe that this theory explains the divergent results of different workers about the second maximum.

Experiments have been carried out here using three-fold and four-fold coincidences. Our experimental arrangement is similar to that used by Clay and Scheen. The top tray consists of seven counters each 2·5 cm. in diameter and 35 cm. long placed in parallel immediately below the lead layer. The distance between the top and bottom trays was about 17 cm. The second maximum is found to occur at a thickness of 14–15 cm. of lead, and it is pronounced in all the curves obtained by an amount greater than the standard deviations. There is also a third maximum at a thickness of 24–25 cm. of lead. This occurs in all the experiments, though it is never as clear as the second maximum.

There was an indication that the second and third maxima were situated at greater thickness with four-fold than with three-fold coincidences. We have tried five-fold coincidences as well, but have not been able to detect any shift in the position of the second and third maxima obtained with the four-fold coincidences. The thickness of the lead layer was changed in steps of 1 cm. in these experiments.



The experiments were carried out under a concrete roof about one foot thick, at Lahore, lat. 31° 33′ N.

Fig. 1 gives a typical curve showing the first, second and third maxima in lead obtained by us using four-fold coincidences. We thank Mr. Taseer for drawing the figure.

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July 26.

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Minor Oscillations of Magnetographs

At the Alibag Magnetic Observatory, two sets of photographic magnetographs have been in use for several years past. The magnetograph room is an insulated cubicle with double walls, double roof and double basement. A working floor or basement of flagstones is supported by trusses several feet above the ground. Isolated pillars with circular guard air-spaces come up through the insulating layers and the working floor of flagstones right from the ground. The Watson magnetographs (horizontal force, H; declination, D; and vertical force, V) and their recorders have rested on these isolated pillars since 1903–4. The La Cour magnetographs and their recorders are on pillars erected only above the working floor, with no rigid connexion to the ground below. The D instrument has been in use since 1936 and the H and V instruments have been in use since 1946.

The Watson and La Cour magnetographs for H and V have nearly the same order of magnification and are equally sensitive; but the La Cour D instrument is more sensitive than the Watson D magnetograph.

A thunderstorm passed over Alibag on June 2, 1955, between 1530 and 1900 hr. I.S.T. While the wind speed did not exceed at any time 25–30 m.p.h., the thunderclaps were very loud and persistent over

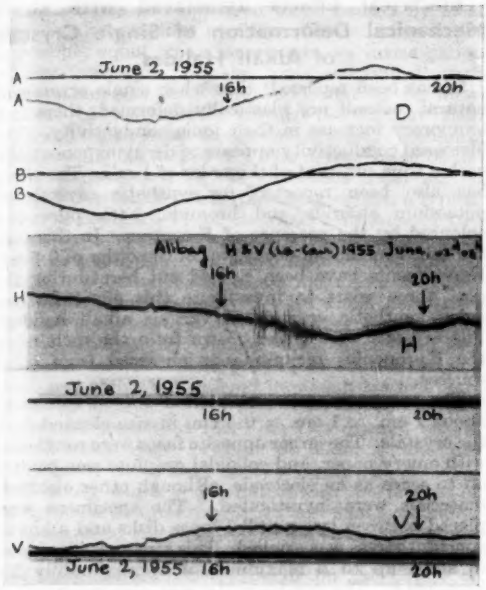

Fig. 1. La Cour magnetograms (*D*, *H* and *V*) during a thunderstorm on June 2, 1955, between 1530 hr. and 1900 hr. I.S.T. *A*, June 02d. 08h. 52m. →; *B*, June 03d. 18h. 41m. →

and near the Observatory. Between 1630 and 1800 hr. I.S.T., the La Cour *H* magnetograph shows (Fig. 1) a large number of oscillations with displacements amounting on either side to 30γ. The La Cour *D* (trace slightly fainter) also shows considerable disturbance at the same time. The *V* trace is not much affected. However, the Watson magnetographs show no disturbance. The La Cour *H* and *D* magnetographs have magnets suspended by fine quartz fibres whereas the magnet of the La Cour *V* has a knife-edge support.

It would be interesting to know if other observatories have recorded similar oscillations, and, if so, the mode of mounting their magnetographs. Ramanathan[1] has discussed the effect at Alibag of lightning discharges on a magnetometer. Records with La Cour *H* and *V* magnetographs had not commenced at that time.

We thank Mr. M. Panduranga Rao for assistance.

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Bombay 5.
July 25.

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Double-Illumination Microscopy

When an unstained preparation is viewed through the microscope by transmitted light (substage), light parts of it may appear black for one of two reasons: either they absorb much light or they reflect much light back towards the light-source. In the latter case, 'black' parts can be lit by incidental (suprastage) light; if the transmitted and incident lights differ in colour, then these parts will be clearly seen against a contrasting background with a marked three-dimensional effect. The reflected light is best supplied through a bullseye (or equivalent) condenser from a standard tubular lamp-house. This arrangement concentrates the reflected light beneath the microscope objective sufficiently strongly to balance the light coming through the substage condenser.

Red (magenta) and green (or blue-green) light filters appear to give the best contrast. For most purposes the transmitted light should be green, the reflected light red. If this arrangement of colours be reversed, there is a reversal of emphasis on the parts of the section presented to the eye. Thus 'normal' illumination of a ground section of bone will emphasize the corpuscle spaces and canaliculi of the Haversian systems; 'reversed' illumination will emphasize the bony matrix and its trabecular form.

This 'double-illumination' is as useful with high powers as with low, and is helpful in teaching. Full technical details will be published elsewhere [see *Irish Journal of Medical Science*, October 1955].

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Interference to the Ultra-Violet Spectrophotometry of Barbiturates

The quantitative analysis of barbiturates in body fluids is now generally carried out by ultra-violet spectrophotometry[1]. The difference in absorption at 240 mμ in 0·5 *N* ammonium hydroxide and in acid gives an accurate measure of the quantity of barbiturate.

Work so far published suggests that this is a reliable technique, as very few interfering substances have been noted. It is possible, however, that certain coumarin anticoagulants or other drugs might interfere, and readings over a wide range of frequencies are therefore taken. During the past three months in this laboratory, an interfering substance that possibly occurs naturally has been found in four livers from various cases of sudden death and in one sample of urine submitted from a drunken person who, it was suspected, might have also taken barbiturate.

The compound has been found to be soluble in ether and phenolic in character, and is therefore extracted together with the barbiturates. The method of extraction used was substantially that of Valov[2].

The similarity of its ultra-violet absorption curve with that of barbiturates in 0·5 *N* ammonia and acid (see Fig. 1) indicates that, if this substance is present, it seriously interferes with quantitative analysis of barbiturate by ultra-violet spectrophotometry. The quantities of this compound present in the liver samples have been such as to suggest barbiturate concentrations of 1–4 mgm. per 100 gm. While work is proceeding on the isolation and identification of this compound, it is felt that its presence should be reported immediately in view of the widespread use of the method. In this laboratory the ultra-violet absorption analysis of the barbiturate fraction from viscera is followed by paper chromatography in an *n*-butanol / 5 *N* ammonia solvent system[3]. In this system the unknown compound runs at R_F 0·95,

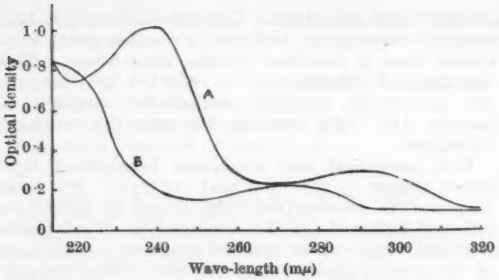

Fig. 1. Curve *A*, in 0·5 *N* ammonium hydroxide; curve *B*, in 0·1 *N* sulphuric acid

thus separating it from all the barbiturates. It also fluoresces blue in ultra-violet light. It does not react with the mercuric sulphate / diphenylcarbazone reagent[3] for barbiturates, but with ferric chloride/ferricyanide[4] gives a blue spot.

A routine check of the ultra-violet ratio of optical densities at 265 mμ and 290 mμ, coupled with examination of the paper chromatogram under ultra-violet light, followed by elution of the fraction of R_F 0·95 with *N*/10 sodium hydroxide, in which its spectrum is the same as in 0·5 *N* ammonium hydroxide, as distinct from barbiturates, will show its presence. If this unknown compound is present, quantitative analysis of the barbiturate must be carried out by ultra-violet spectrophotometry after separation of an aliquot of the extract from the interfering substance on a paper chromatogram.

The reason for suspecting that these observations may be linked with a natural compound, possibly of seasonal origin, is not only the variety of cases in which it has been observed, but also the fact that in one case a compound having extremely similar ultra-violet absorption characteristics was isolated from the contents of a stomach. In this case the material was treated with acid ammonium sulphate[5], and the aqueous filtrate was then extracted first with ether, and, after making alkaline with ammonia, again with ether and finally with chloroform. Only in this last chloroform extract was the chromophoric group found. From the liver of this same person there was isolated from the 'phenolic' ether-soluble fraction a compound with the similar ultra-violet chromophore. This, coupled with the previous fact, suggests the substances may be metabolically related. Work is proceeding on the identification of both these compounds.

I thank Dr. F. G. Tryhorn, director of this Laboratory, for advice and for permission to publish this communication.

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Electrical Effects associated with the Mechanical Deformation of Single Crystals of Alkali Halides

It has been reported[1] that when single crystals of natural rocksalt are plastically deformed, there is a temporary increase in their ionic conductivity. The increased conductivity appears to decay exponentially with a time constant of the order of 1 min. The effect has also been reported[2] for synthetic crystals of potassium chloride and bromide, both pure and coloured by the presence of *F*-centres. In this case the time constant of decay was of the order of 0·5 sec. Experiments have been carried out here during the past three years to investigate this effect further, using synthetic crystals of various alkali halides[3]. The crystals were either grown from the melt using the Kyropoulos technique or obtained from other sources.

The measurements were carried out on specimens about 1 cm. × 1 cm. × 0·5 cm. in size cleaved from the crystals. The larger opposite faces were roughened with emery paper, and colloidal graphite was painted on to serve as an electrode, although other electrode materials were investigated. The specimens were placed between two parallel brass disks and a known constant stress was applied. This stress was increased in steps up to a maximum of approximately 200 kgm./cm.^{2}. The conductivity was also measured at the same time by means of a sensitive electrometer valve and d.c. amplifier. The ionic conductivity of the specimen was presented as a deflexion on the screen of a cathode-ray oscilloscope, and any change with time could be observed or photographed.

An increase in the conductivity of the following crystals (sources indicated in brackets) was observed under the influence of plastic deformation: potassium chloride (Harshaw Chemical Co., Messrs. Hilger, Ltd., and Durham); sodium iodide (Messrs. Hilger, Ltd.); and potassium iodide (Harshaw Chemical Co.). An increase of conductivity was also observed in sodium chloride from the Harshaw Chemical Co. and potassium bromide from Messrs. Hilger, Ltd., but only at high stresses (> 40 kgm./cm.^{2}). It was notable, however, that no increase of conductivity occurred in samples of sodium chloride from Messrs. Taylor, Taylor and Hobson, Ltd., Messrs. Hilger, Ltd., Dr. Korth, Universities of Aberdeen and Durham. Where the increased conductivity was observed, it was often quite large (hundredfold) and appeared to be proportional to the stress applied. Once the increase had been obtained for any given stress and had decayed, it could only be made to reappear by exceeding the value of the stress previously reached. The time constant of decay of the increase of conductivity was in all cases in the range 0·4–1·1 sec. The experiments on the change of conductivity were carried out over a range of temperature. In general, the effect decreased rapidly with increasing temperature, and at a temperature of 400° C. it was almost negligible.

A second effect was also discovered[3], and this has also been reported independently by Fischbach and Nowick[4]. It was found with all the specimens of alkali halides mentioned above that on the application of a stress a potential appeared between the electrodes on the surface of the crystal. The sign of the potential was quite random for any given specimen, and indeed often changed in the course of an experiment, for example, with increasing stress. The potential effect was very dependent upon the state of the

crystal surface and appeared to be caused by local stress inhomogeneities at the surface. Using so far as possible equal stress increments, an investigation of the variation of the potential effect with temperature was made. It appeared to be independent of temperature up to 180° C. but then decreased with increasing temperature, becoming almost negligible at 250° C. The actual value of the potential developed at the electrodes depended on the input resistance of the measuring circuit, a typical variation being 10 V. for an input resistance of 10^{11} ohms to 0·1 V. for 10^{9} ohms. The crystal thus behaved as a low-power potential source. The appearance of a potential under stress was also a transient phenomenon and it decayed with time. Generally, the time constant of decay was rather smaller than for the conductivity change, being about 0·3 sec. The potential effect was present in all the crystals mentioned above but differed in magnitude from one crystal to another.

It would seem that there are two distinct effects present when single crystals of alkali halides are mechanically deformed: first, a change in the ionic conductivity which is associated with the process of homogeneous strain throughout the crystal; secondly, the appearance of a potential at the electrodes caused by stress inhomogeneities. The latter is suggested since the potential effect depends on the nature of the crystal surface and it can appear when the value of the stress applied to the crystal as a whole is less than the yield stress for plastic flow.

It is hoped to publish a fuller account of this work elsewhere. Acknowledgments are made to the Department of Scientific and Industrial Research for a maintenance grant (T. L. G.), to the Research Fund of the Durham Colleges for a grant for apparatus, to the Physics Department, University of Aberdeen, Messrs. Hilger, Ltd., Dr. K. Korth, and Dr. J. J. Markham for gifts of crystals, and to Prof. J. E. P. Wagstaff for laboratory facilities placed at our disposal.

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Formation of Complexes of Fluorocarbons and Fluorocarbon Derivatives with Polar Hydrocarbons, Polar Polymers, Proteins and Polypeptides

Various studies started four years ago have suggested that complexes form between —CF_2 and —CF_3 groups and polar groups such as —OH, —NH_2, —SH, —*R*NH, etc. This interaction appears to be independent of the position of these polar groups and has been observed in solution as well as in solids. Thus, it is quite different from urea-hydrocarbon complexes[1].

In attempting to elucidate the nature of the complex, fluorocarbon acids, the corresponding salts and other fluorocarbon derivatives have been found to protect proteins against heat, various chemical denaturants such as urea, etc.; for example, it has been possible to heat a 1 per cent bovine serum albumin solution to as high as 175° C., store it at that temperature for an hour or more, and find no physical or biochemical evidence of denaturation.

Under slightly different experimental conditions, it was found that the longer-chain fluorocarbons were much more active as protein coagulants[2] than the shorter-chain corresponding derivatives. Since in the case of the carboxylate acid derivatives, for example, the acid strength is essentially independent of the chain-length, it would be necessary to postulate some effect of the fluorocarbon chain-length on the protein, probably through the hydrogen-bond network, through the polypeptide chain and/or through the polar groups on the protein surface. The protective action mentioned above is thought to involve a strengthening of the hydrogen-bond network of the protein molecule. Other evidence gathered as to the existence and nature of the complex is summarized as follows.

The curve of Δn (change in refractive index), with c, concentration, in systems forming micelles, shows a change in slope when the critical micelle concentration is reached. This is observed in paraffin-chain salts[3], perfluoroacids and other fluorocarbon derivatives. When the solvent is changed from water to 1–5 per cent ethanol in water, Δn has a maximum as a function of c for perfluoroacids. Conductivity measurements (Klevens, H. B., and Vergnolle, J., unpublished results) indicate little or no interaction between the alcohol and the fluorocarbon ion. There are also discontinuities in the curves of surface tension versus concentration for solutions of fluorocarbon derivatives in mixed solvents (alcohol–water)[4]. No such discontinuity is observed in paraffin-chain salts dissolved in alcohol–water mixtures. Further, in contrast to the linear decrease in critical micelle concentration of the paraffin-chain salts with increase in alcohol concentration[5], a larger initial decrease in this concentration of perfluorocarbon acids and other derivatives is observed upon the addition of various polar hydrocarbons, followed by a region in which there is little further decrease in critical micelle concentration with increase in the concentration of polar additive[6].

These results indicate the presence of two components in solution: (1) a complex between fluorocarbon and alcohol; and (2) a non-complexed fluorocarbon.

In a study of the spectra of propanol in various solvents[7], it was observed that there is a marked hypsochromic shift when the solvent is changed from a hydrocarbon to a fluorocarbon. This blue shift is much more than is observed for compounds such as the aromatic hydrocarbons, where spectra are usually only sharpened by change of solvent from hydrocarbon to fluorocarbon.

Nuclear magnetic resonance studies (measurements made for me by G. R. Holzman, J. H. Anderson and W. Koth, of the Mellon Institute, and by J. N. Shoolery, of Varian Associates) of perfluoro-octanoic acid in water, in a 1 per cent butylamine solution, and when adsorbed on bovine serum albumin molecules, show definite and marked differences in their —CF_3 spectra. For equivalent fluorine concentrations in the three systems studied, there was a relative decrease in the —CF_2 spectra and a correspondingly much greater decrease in the —CF_3 spectra as the solvent was changed from water to

butylamine in water, and an even greater change was observed when protein was present.

These latter measurements are the first definitive ones which support the above hypothesis as to direct interaction between $—CF_2$ and $—CF_3$ and various polar groups.

Ultracentrifuge, viscosity and light-scattering measurements and partial molar volume data on these fluorocarbon–polymer systems also indicate some interaction. Details of these measurements will be published shortly.

The major portion of this work was done and various concepts and conclusions were reached, while I was an Advanced Research Scholar under the Fulbright Act in Paris, 1951–52. Further confirmatory evidence was obtained at the University of Minnesota and in the Graduate School of Public Health at the University of Pittsburgh.

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Direct Spectrophotometric Determination on Paper of Chromatographic Spots of Cobalt and Copper

Quantitative paper chromatography is likely to become a general micro-analytical method on account of its penetrating power and rapidity. Quantitative determination of spots can be speeded up by direct titration of the spots on paper, with a reproducibility of ± 3–4 per cent in the case of molybdenum and vanadium[1]. Copper, cobalt[2], nickel and chlorides have already been studied, too.

Direct photometry or densitometry in white light has been applied to the measurement of chromatographic spots of vanadium[3] revealed with oxine, of phosphorus[4], of cobalt and copper[2]. The final complex opacity includes opacity of the paper, which has to be checked millimetre by millimetre before even chromatographic development, and has to be taken into account at the end for the piece of paper at the exact place of the spot. This is not practical when the spot travels too far away from the starting line[5].

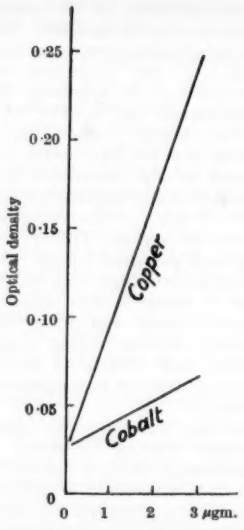

Fig. 1

Direct spectrophotometry on paper for spots revealed chromatographically has a more general and practical application. For example, a definite wave-length can be used for these measurements, as when operating on solutions. This wave-length is chosen after drawing both absorption curves, that for the complex and that for the reagent; and it corresponds to the spectral region where these two curves show the greatest absorption difference.

Organic reagents and complexes are so insoluble in water that very little of them is given up to this solvent from a strip of paper carrying a given quantity of such substances. Photometric measurements can be carried out, however, by slipping the strip of paper bearing the spot or the vaporized reagent between the wall of the usual spectrophotometric cell and a prismatic calibrated glass adapter, with a few drops of water to eliminate air bubbles. Optical densities of vaporized strips with α-nitroso-β-naphthol or

Optical Density for 3 μgm. of Cobalt revealed with α-Nitroso-β-Naphthol

λ = 850 mμ. F = 0·040 mm.

Paper blank chromatographed	Paper blank chromatographed vaporized	Mean values chromatographed	Mean values not chromatographed
0·125	0·130 0·130 0·130 0·129 0·130 0·130 0·130	0·064 0·064 0·063 0·065 0·066 0·065	0·050 0·051 0·050 0·049 0·050 0·041
	M/24 0·1297	M/18 0·064 ± 0·47 per cent	M/18 0·050 ± 0·39 per cent

Optical Density for 3 μgm. of Copper revealed with Rubeanic Acid

λ = 660 mμ. F = 0·095 mm.

Paper blanks chromatographed vaporized	Mean values chromatographed	Mean values not chromatographed
0·010 0·010 0·011 0·011 0·011 0·010 0·009 0·010 0·010	0·245 0·246 0·246 0·246 0·245 0·245 0·246 0·245 0·244 0·245 0·246 0·244 0·245 0·245 0·245 0·246	0·239 0·238 0·239 0·240 0·239 0·239
M/18 0·0103	M/18 0·2453 ± 0·01 per cent	M/18 0·239 ± 0·5 per cent

rubeanic acid are so reproducible in this way that one can set the zero of the apparatus on these vaporized strips. The optical density of the vaporized spot is then measured directly from this zero. There is consequently no need to measure blanks, except for control, and the position of the spot in the chromatogram is of no importance.

Reference diagrams have been drawn from 0·1 to 3 μgm. of cobalt and copper. Concentrations can be checked within these limits with a reproducibility less than 0·5 per cent.

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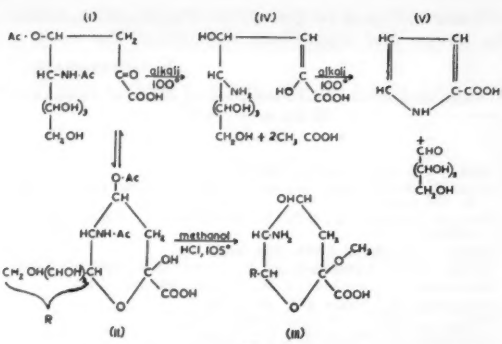
Structural Relationship between Sialic Acid, Neuraminic Acid and 2-Carboxy-Pyrrole

An interesting field of biochemical research was opened when Blix[1] isolated from bovine submaxillary gland mucin a crystalline reducing acid, named sialic acid[2]. Its most probable composition is given as $C_{13}H_{23}NO_{11}$ or $C_{13}H_{21}NO_{10}.H_2O$. Bovine sialic acid contains an *N*-acetyl and an O-acetyl group, one primary alcohol group and a total of five hydroxyl groups[3]. Consumption of free iodine, when sialic acid is titrated with hypoiodite, and of one molecule of hydrogen, when the acid is submitted to treatment with sodium borohydride, is interpreted by Blix *et al.*[3] as indicating the presence of a free aldehyde group. The liberation of less than one mole carbon monoxide per mole sialic acid upon treatment with sulphuric acid would suggest the presence of an α-hydroxy group[3].

Neuraminic acid in the form of its alkali-stable methoxy derivative was first isolated by Klenk from gangliosides[4] and more recently from bovine submaxillary gland mucin and from a urine mucoprotein[5], its composition being $C_{11}H_{21}NO_9$ or perhaps $C_{10}H_{19}NO_8$. This substance has no reducing power, but is ninhydrin-positive[4]. Sialic acid and the methoxy derivative of neuraminic acid are characterized by the purple colour they give on heating with Ehrlich's *p*-dimethylaminobenzaldehyde reagent even without alkali pretreatment (direct Ehrlich reaction), by the violet colour they produce on treatment with Bial's orcinol reagent and by the considerable humin formation on heating with dilute mineral acid.

A reducing, nitrogen-containing compound responding to treatment with Ehrlich's and Bial's reagents and with dilute mineral acid in exactly the same manner as do sialic and neuraminic acids was isolated in our laboratory as the product of an enzyme-substrate interaction[6,7]. The influenza virus enzyme and the receptor-destroying enzyme of *Vibrio cholerae* were found to liberate from ovomucin and from homogeneous mucoproteins (prepared from human urine and from bovine submaxillary gland mucin respectively) the above compound, which by dialysis was readily separated from the reaction mixture. Its



properties suggested to Odin[8] and Klenk[5] close similarity to, if not identity with, sialic and neuraminic acid respectively. Upon treatment with mild alkali (0·1 *N* sodium carbonate, 100°, 20 min.) 2-carboxy-pyrrole was obtained from the enzymatically released product in a yield of about 0·05 per cent of the pure mucoprotein[9,10]. The same pyrrole compound was formed in a yield of 0·05 per cent from the homogeneous mucoproteins, known to contain sialic acid, by treatment with 0·63 *N* barium hydroxide for 8 hr. at 100° (ref. 10; see also Hiyama[11]).

The proposed structures for sialic acid (I ⇌ II) and the methoxy derivative of neuraminic acid (III) would account for all relevant observations. The direct Ehrlich reaction given by I and III may be visualized as proceeding via IV to V, the benzaldehyde acting as a trapping agent for the otherwise acid-labile pyrrole derivative; the alkali stability of III arises from its acetal structure. Neuraminic acid (IV) may be regarded as an aldol type of condensation product of 2-amino-2-deoxy-hexose with pyruvic acid, the aldol type of linkage rendering recovery of the amino-sugar by acid treatment impossible[2,4,7]. The location in this condensation product of a keto, a hydroxyl and an amino-group in the <2,4,5> position provides optimal conditions for cyclization to pyrrole.

Direct evidence for the key reaction IV → V of the diagram was afforded by condensing glucosamine with pyruvic acid in alkaline medium heated for 20 min. at 100°. In this way, 0·5 gm. glucosamine hydrochloride and 5·1 gm. sodium pyruvate, dissolved in 500 ml. 0·17 *N* sodium carbonate, yielded about 1 per cent of the theoretical amount of 2-carboxy-pyrrole. This yield is of the same order of magnitude as that obtained from bovine submaxillary mucoprotein, assuming, as seems most likely[3], that its sialic acid content of 17 per cent is responsible for the production of 2-carboxy-pyrrole. 2-Carboxy-pyrrole was identified chromatographically and spectrophotometrically as described in detail elsewhere[10]; its quantity was calculated by means of the molecular extinction coefficient[10].

Strong support for the structures shown in the diagram is afforded by the finding[12] that *N*-acetyl-neuraminic acid, but not (III), is converted to (V) on treatment with alkali.

The ready conversion by alkali to (V) of (I) and of the enzymatically released product, with our recent observation that concomitant with the enzymatic release of this product the sialic acid content of the bovine mucoprotein is reduced by 64 per cent, leaves little doubt on the identity of the two compounds.

I am indebted to Dr. J. W. Cornforth, London, for advice and suggestions throughout the work.

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Occurrence of *n*-Nonadecanoic Acid in Ox Perinephric Fat

When *n*-heptadecanoic (margaric) and *n*-pentadecanoic acids[1] were isolated from hydrogenated mutton fat, it was anticipated that all the normal odd-numbered fatty acids appropriate to the series would be present in natural fats. Subsequent evidence points to this being the case. Apart from the occurrence of *n*-C_{15} and *n*-C_{13} acids in unhydrogenated butterfat, and of *n*-C_{15} and *n*-C_{17} acids in unhydrogenated fish-liver oil, *n*-C_{11} acid has been located in hydrogenated butterfat, and all the acids (odd and even) from C_2 to C_{19} have been shown to be present in the volatile acids of ox perinephric fat.

We now report the isolation from hydrogenated ox perinephric fat (sample *J*/21) of trace quantities of the C_{19} member, *n*-nonadecanoic acid. The chemical and physical properties of the fraction isolated (denoted *U*74*S*3*S*, weight 0·20 gm.) were as follows: saponification equivalent 297·5 (calculated for $C_{19}H_{38}O_2$, 298·5); melting point 67·5–68·0° (literature records are 68·65° [2] and 68·5° [3] for *n*-nonadecanoic acid); X-ray long spacing 43·77 A. (± 0·5 A.) for sample prepared from benzene (literature records[4] 44·13 A. for sample prepared from acetone). Were this fraction 17-methyloctadecanoic acid, its melting point would be less than 1 deg. below that of the normal isomer (literature records[5] 67·3–67·8°), but its X-ray long spacing[6] would be of the order of 36·2 A.

Although *n*-nonadecanoic acid has been prepared synthetically it has not hitherto been isolated from a natural or a hydrogenated fat.

Further details of this work will be published later.

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Volatile Fatty Acids in Phospholipids

Using the micro-technique of James and Martin[1], it has been established that bovine muscle phospholipids contain small amounts of volatile fatty acids, and it is possible that this finding can be extended to animal phospholipids in general. Hitherto, in the absence of techniques for the micro-estimation of the low molecular-weight fatty acids, it has generally been accepted that the fatty acids of phospholipids tend to be of high molecular weight only. A consecutive series of normal fatty acids from C_2 to C_{10} has been identified in ox perinephric fat[2].

To minimize post-mortem enzymatic hydrolysis of the lipids, the bovine muscle, which had been freed from visible fat, was finely minced and heated in boiling ethanol within an hour of slaughter. The ethanol-ether extracts of the dried tissue, from which non-lipid impurities had been removed on cellulose[3], were separated into phospholipids and glycerides. A preliminary separation was carried out making use of their differing solubilities in acetone, and from the impure phospholipid thus obtained (phosphorus content, 3·7 per cent) further glyceride was separated by using silica gel previously activated for 24 hr. at 120° C. Glycerides were eluted with chloroform[4], while under the same conditions phospholipids were adsorbed on to the silica gel. The phospholipids (phosphorus content, 3·9 per cent) were then eluted with methanol. Purified solvents were used in the extraction and separation procedures. It was found that the muscle contained 2·71 per cent glycerides and 0·57 per cent phospholipids.

The phospholipids were hydrolysed by refluxing with 1 per cent sulphuric acid in ethanol for 3 hr., and then with approximately 13 per cent potassium hydroxide in ethanol for 5 hr. After removal of the unsaponified material by ether extraction (6·9 per cent by weight) the fatty acids were steam-distilled. The soaps of the acids volatile in steam were concentrated to an approximately normal solution and an aliquot was acidified and applied to the gas-liquid chromatogram by the procedure suggested by James and Martin[1]. The column was operated at 137° C.

The acids identified were acetic, octanoic, propionic, hexanoic, butyric, *iso*-valeric and valeric in decreasing amounts on a molar basis. These volatile acids represented approximately 0·17 per cent by weight of the total fatty acids present in the muscle phospholipids.

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Protection of Deoxyribonuclease from Ionizing Radiation by Adsorbents

The present communication presents experimental evidence which indicates that adsorption of deoxyribonuclease on a liquid–solid interface affords protection of enzymatic activity from radiation damage. Other means of protecting enzymes in aqueous solutions have been described by various investigators[1–6], but, to our knowledge, no information is available concerning the protective effect of adsorption.

Crystalline deoxyribonuclease (DNase crystalline, purchased from Worthington Biochemical Co., Freehold, New Jersey) with a *p*H optimum at 7·5 was used in all experiments. The enzymatic activity was determined according to Kowlessar *et al.*[7]. Although the enzyme adsorbed on cellulose powder could not be eluted, the suspension of the adsorbed enzyme showed enzymatic activity 10–35 per cent less than that noted when the enzyme was in aqueous solution. 10 ml. of a solution containing 5 μgm. of the enzyme and 5 mgm. of cellulose powder (Whatman standard grade cellulose ashless powder) was irradiated with 1,090 r. in a glass centrifuge tube while being stirred. The radiation factors were: 206 kVp., 1,453 r. per min., 20 m.amp., no filtration and target–object distance of 10·3 cm.

In all experiments, the enzymatic activity of the adsorbed and non-adsorbed deoxyribonuclease fractions, separated by centrifugation, was determined before and after exposure to X-rays. In the case of pre-exposure samples, the system was equilibrated first by stirring for 20 min. A typical experiment (2*a*, *b*) in Table 1 shows that the non-adsorbed fraction of the enzyme was almost completely inactivated, whereas the adsorbed fraction of the enzyme was protected significantly from inactivation by X-rays.

In another experiment (Table 1, 3*a*, *b*) the cellulose was separated after thorough mixing with the deoxyribonuclease solution. The resultant supernatant solution and precipitate were irradiated separately, the precipitate having been suspended in a volume of distilled water equal to that of the supernatant phase. The results of five experiments demonstrate again that the adsorbent protects the enzyme.

The degree of protection afforded the enzyme by the adsorbent is a function of the amount of enzyme in the adsorbed state. This is illustrated by the results in Table 2 relating the amount of cellulose added to the system to the degree of inactivation of deoxyribonuclease.

Varying degrees of protection of deoxyribonuclease from X-radiation are obtained with different adsorbents such as ion-exchange resins, silica gel, 'Celite' and bone ash. This suggests that the mechanism by which adsorption protects the enzyme is not specific for any one adsorbent. The biological implications of such a phenomenon are exemplified by preliminary observations which suggest that deoxyribonuclease is protected from inactivation by X-rays when adsorbed on rat spleen mitochondria.

Several hypotheses may be advanced in order to explain the observed protection by adsorbents: (1) the ratio of free radicals to enzyme molecules in the adsorbed fraction is much lower than it is in the supernatant phase; (2) the free radicals do not migrate freely into the micellar space; or (3) competitive reactions on the surface of the adsorbent decrease the number of free radicals available for enzyme inactivation. Since the number of adsorbent particles involved in this system is much less than the number of molecules of the usual protective reagents, and since little protection is afforded the enzyme in the supernatant phase by the dispersed adsorbent (Table 1–2), it seems unlikely that the protective effect obtained is of the customary competitive variety[1,2,5].

These experiments and others of a similar nature will be published in detail elsewhere.

Table 1. Effect of X-Irradiation on the Deoxyribonuclease–Cellulose System

System	Enzyme activity (per cent remaining) Non-irradiated control	After irradiation	*R**
(1) Deoxyribonuclease	100	13	13
(2) Deoxyribonuclease + cellulose, irradiated together and then separated			
(*a*) supernatant	66	29	44
(*b*) precipitate	48	5	11
(3) Deoxyribonuclease + cellulose, irradiated after separation into solid and liquid phase	18	14	78
(*a*) supernatant	100	52±7	52
(*b*) precipitate	100	84±20	84

* $R = \frac{\text{Enzyme activity after irradiation}}{\text{Enzyme activity of non-irradiated control sample}} \times 100.$

The enzyme activities in experiments (2), (2*a*) and (2*b*) are referred to (1) as 100, whereas in (3*a*) and (3*b*) the respective non-irradiated sample serves as reference point.

In (3*a*) and (3*b*) the standard deviations are also shown.

Table 2. Relationship between the Degree of the Protection and the Amount of the Adsorbent

Amount of cellulose (mgm.)	Per cent of enzyme + activity remaining after irradiation	Per cent of activity with supernatant*
0	39 ± 14	100
0·1	36 ± 7	69
1	35 ± 1	84
5	72 ± 13	49
10	92 ± 10	20
30	80 ± 10	6
100	100	—

* Per cent of activity $= \frac{\text{Activity in the supernatant}}{\text{Total activity}} \times 100.$

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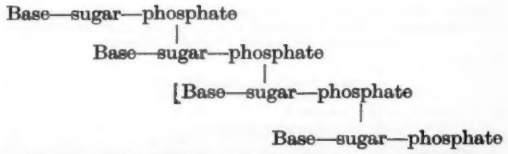
A New Method for 'Hydrolysis' of Nucleic Acids with Phosphorus Pentoxide

Nucleic acids consist of nucleotides linked together by ester linkages between the phosphate group of one and the ribose group of another nucleotide as shown below:



Hence it should be possible to separate the bases in free form if the sugar links are broken down. Sugars are known to be susceptible to hydration.

Table 1. Phosphorus Pentoxide Hydrolysis of Deoxyribonucleic Acid Isolated from Tumour Tissue

Kjeldahl nitrogen value for original deoxyribonucleic acid, 10·5 per cent. Nitrogen value calculated from the bases isolated, 9·3 per cent.

	(I) Found (μgm. base/mgm. deoxyribonucleic acid)	(II) Calculated nitrogen value from col. I (μgm. nitrogen/mgm. deoxyribonucleic acid)
Adenine, Thymine	110*	44*
Guanine	70	33·6
Cytosine	40	15·2
Uracil	—	—
	Total nitrogen	92·8

* Adenine and thymine have the same R_F values for the solvent used, hence in the calculation of nitrogen values the mean value for adenine and thymine is used.

Experiments were therefore carried out with the view of breaking down the ribose bridges with a dehydrating agent such as phosphorus pentoxide in order to find if the free bases are liberated. The results form the basis of the present preliminary report of a new method of 'hydrolysing' the nucleic acids.

Nucleic acids separated from biological materials by the method of Chargaff *et al.*[1] and commercial samples of deoxyribo- and ribo-nucleic acids were used for the investigations. To 10 mgm. of dry nucleic acid powder in a clean dry test-tube, sufficient phosphorus pentoxide was added to cover the nucleic acid. The tube was stoppered, shaken vigorously and then heated in an electric oven at 150° C. for two hours. To the charred mass 2·5 ml. of 0·1 *N* hydrochloric acid was added to dissolve the bases. The solution was filtered to separate the carbon particles. The clear solution was then spotted on a Whatman No. 1 filter paper and an ascending chromatogram run overnight using 79 per cent saturated ammonium sulphate solution, 19 per cent water and 2 per cent *iso*propanol as the solvent[2]. After drying the chromatogram at room temperature, the positions of the purines and pyrimidines were located by taking a contact print with ultra-violet light[4] on Kodak rapid reflex document paper (*DOUSTAT*, 23). Corresponding areas on the chromatogram were then cut out and eluted by overnight extraction with 10 ml. of 0·1 *N* hydrochloric acid. The bases were estimated quantitatively[2], using the Beckman spectrophotometer (Model *D.U.*) at 265 mμ. The results of some analyses of tumour deoxyribonucleic acid are shown in Table 1. Here it will be seen that the Kjeldahl nitrogen value for the isolated deoxyribonucleic acid is 10·5 per cent and that accounted for by the isolated bases is 9·3 per cent, thus indicating that the hydrolysis and the recoveries are fairly complete.

The treatment with phosphorus pentoxide is a fairly drastic one, and before the usefulness of the method could be assessed it is necessary to study its effects on pure purines and pyrimidines, to rule out the possibility of destruction of the bases during the process. This has been tested by recovery experiments after treating pure samples of the bases individually with phosphorus pentoxide. The results are shown in Table 2.

Table 2. Recovery of Pure Purines and Pyrimidines subjected to Treatment with Phosphorus Pentoxide and Subsequent Separation by Paper Chromatography

	Quantity of base taken (μgm.)	Quantity of base found (μgm.)	Percentage recovery (per cent)
Adenine	250	250	100
Guanine	250	235	94
Cytosine	250	245	98
Uracil	250	240	96
Thymine	250	230	92

It can be seen that the recoveries are fairly good. Besides the recovery experiments, two other criteria were employed for confirming that the phosphorus pentoxide treatment does not affect the bases, namely: (1) ultra-violet absorption spectra; and (2) the R_F values of the bases after treatment with phosphorus pentoxide. The absorption spectra and the R_F values of the bases were unaffected by the treatment.

It appears, therefore, that the new method brings about complete hydrolysis without in any way affecting the recovery of the bases. Further work on this method is in progress.

Thanks are due to Dr. V. R. Khanolkar and Dr. A. R. Gopal-Ayengar for advice and criticism, and to Dr. T. B. Panse for facilities to use the Beckman spectrophotometer.

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Effect of Denervation on the Histochemical Appearance of Cholinesterase at the Myoneural Junction

The sensitivity of the motor end-plate to acetylcholine is known to increase after denervation. Many workers have investigated by chemical analysis the cholinesterase content of denervated muscle in an attempt to explain this increased sensitivity. The results have, however, been confusing. Marnay and Nachmansohn[1] reported that the cholinesterase content of muscle increased following nerve section, while Couteaux and Nachmansohn[2] and Stoerk and Morpeth[3] found that it became reduced. Sawyer *et al.*[4], working on skeletal muscle of the rat, guinea pig and rabbit, reported that the concentration of cholinesterase at first became reduced after nerve section and later became increased to considerably more than its normal complement. Since the results obtained by chemical analysis include the cholinesterase present in the terminal nerve fibres[5] and also that present in muscle other than at the motor end-plate, it seemed desirable to investigate the problem using a histochemical method and to confine the study to the cholinesterase content of the motor end-plate.

Fourteen guinea pigs, seven males and seven females, aged about one year were used for the present investigation. The animals were anæsthetized with ether and the sciatic nerve was cut in mid-thigh. One animal of each sex was killed by a blow on the back of the neck at the seventh, eleventh, fifteenth, nineteenth, twenty-second, twenty-eighth and forty-fifth days following nerve section. The denervated gastrocnemius was removed from each animal, and at the same time the normal gastrocnemius was

removed from the other leg to serve as a control. The specimens were fixed in 10 per cent formol saline for 6 hr., and frozen sections 50μ thick were cut and then washed in distilled water for 1½ hr. Sections from the denervated and control gastrocnemius muscles were then processed using the histochemical technique described by Koelle[6] and modified by Couteaux and Coërs[7]. To ensure adequate control, a denervated and a normal control muscle section from the same animal were always incubated together for exactly the same length of time. The cholinesterase appearances were assessed by studying the concentration and distribution of the copper sulphide precipitate at the motor end-plate.

All the control muscle sections showed that the cholinesterase at the motor end-plate is situated in the walls of gutters on the surface of the muscle fibres and is present in the form of a series of horseshoe-shaped plates as described by Couteaux and Taxi[8]. The muscles which had been denervated for seven days showed that the concentration and distribution of cholinesterase at the motor end-plate were the same as in the controls. In the muscles which had been denervated for eleven days, the concentration of cholinesterase was slightly reduced compared with the controls, while in those which had been denervated for fifteen days the concentration of the cholinesterase was still further reduced and the gutters were less well defined, the edges being irregular. After denervation for nineteen and twenty-two days, it was difficult to make out the normal outline of the motor end-plate even in muscle sections which and been incubated for sixty minutes; the cholinesterase was greatly reduced in amount and its distribution was uneven; and the horseshoe-shaped plates were no longer visible. In those muscles which had been denervated for twenty-eight days the cholinesterase could only just be recognized as a faint shadow against the pale background of the muscle fibres. No cholinesterase was found to be present in the motor end-plates of muscles denervated for forty-five days. Throughout the investigation the results in both sexes, as would be expected, were identical.

These preliminary observations show that the cholinesterase concentration at the motor end-plate of the gastrocnemius muscle of the guinea pig begins to become reduced at about the eleventh day following denervation, and this reduction progresses until at the forty-fifth day no cholinesterase can be found. This gradual reduction in the cholinesterase concentration at the motor end-plate may be partly responsible for the increased sensitivity of denervated muscle to acetylcholine.

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Sources of Platelet Factor for the Thromboplastin Generation Test

The thromboplastin generation test of Biggs and Douglas[1] is of great assistance in the diagnosis of hæmorrhagic diatheses characterized by defective thromboplastin generation. One modification, due to Bell and Alton[2], substitutes the more convenient human brain extract for the platelet suspension. Human brain is not a readily available material, and the preparation of the extract from it is laborious and time-consuming.

Platelet factor is believed to be a phospholipid. Soybean is a readily available source of phospholipids, and soybean phospholipid has been used for counteracting thrombocytopenic bleeding in X-irradiated dogs[3]. A preparation similar to that of White *et al.*[3] was prepared by their method from the commercially available soybean product, 'Lecithin Emulgo No. 4'. It is a light-tan coloured powder, rapidly darkening and becoming sticky on exposure to air at 20° C. The yield is more than 50 per cent of the starting material. The powder is homogenized in physiological saline at a concentration of about 10 mgm./ml. to make the stock solution for the thromboplastin generation test. It is stored at − 20° C. It is diluted before use to from 1 : 50 to 1 : 200 with physiological saline to obtain clotting times with normal bloods of 10 ± 1 sec. Both in Cambridge and the United States (personal communication, W. N. Bell), the soybean suspension has been substituted for platelet suspension in the thromboplastin generation test and has proved satisfactory in the diagnosis of hæmophilia and Christmas disease (Fig. 1). It is intended to use it in further studies on abnormal bloods as these become available in Cambridge.

Preliminary experiments have suggested that the Bell brain extract and the soybean phosphatide are

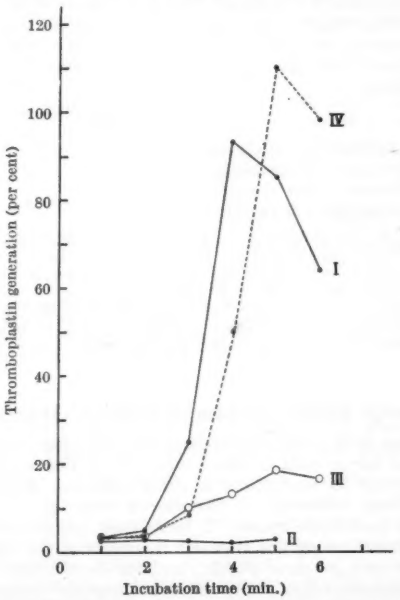
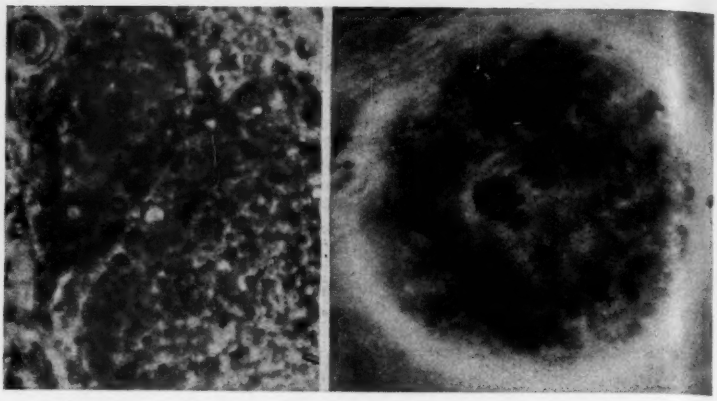


Fig. 1. Abnormal bloods in the thromboplastin generation test using soy phospholipid in place of platelet suspension. I, Normal plasma and serum; II, hæmophilic plasma and normal serum; III, Christmas disease plasma and serum; IV, Christmas disease plasma and normal serum

similar in nature. Further proof has been obtained by chromatographing the two materials on Whatman No. 3 paper impregnated with silicic acid. The papers were developed with 30 per cent methanolic chloroform by the ascending method, dried, sprayed with 0·2 per cent butanolic ninhydrin, heated at 120° for 7 min., and, after noting the position of the positive spots, treated with phosphomolybdic acid and stannous chloride. The extracts both contain a small amount of ninhydrin-positive material of R_P *c.* 0·0 together with a large amount of choline-containing material of R_P 0·90–1·00. A small amount of choline material stays at the starting point. Further work in progress is directed towards the identification of the active material. It is to be noted that it is very difficult to obtain papers with a uniform degree of impregnation with silicic acid. It is therefore necessary to compare compounds directly on the same paper.



Golgi bodies of: (1) *Schistocerca gregaria*, × 750; (2) *Laccotrephes rubra*, × 1,600

Work with the thromboplastin generation test for a period of two years has confirmed its usefulness as a diagnostic test; but as a method of assay for phospholipid material it suffers from the defects of most biological tests—the degree of accuracy is never better than ± 20 per cent—together with a pronounced personal error in finding the exact moment of clotting. At the faster end of the scale a difference of one second causes considerable error. It has also been suggested elsewhere[4] that the degree of division of phospholipid material in suspension partially determines its biological activity. The effect of suspension-size has not yet been determined in this laboratory.

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Golgi Bodies in Nerve Cells of Insects

Some time after the publication of Shafiq's papers[1] on the nerve cells of the locust, Prof. Vishwa Nath asked me to undertake a comprehensive study of the Golgi material in the nerve cells of invertebrates and vertebrates. I have just completed my investigations on the thoracic neurones of the locust, *Schistocerca gregaria* Forsk., and the local water-bug, *Laccotrephes rubra*. My observations are based on the study of neurones of the fifth instar and immature adults of locust and adult water-bugs.

Schistocerca gregaria Forsk. The Golgi bodies (lipochondria of Shafiq) of the living neurones of this locust, when examined under the phase-contrast microscope, show a highly refractile dark cortex and an almost colourless medulla. Besides, there are smaller, highly refractile, homogeneous Golgi spheres. The Golgi bodies can be stained with the vital dyes, neutral red and methylene blue; but it is the medulla of the Golgi body which alone takes up the dye. From this it is concluded, in conformity with Shafiq[1] and Roque[2], that the medulla of the Golgi body is a vacuole with acidic contents (Fig. 1).

In paraffin sections of Helly's fixed – post-chromed material and stained with sudan black, the Golgi spheres present a thick outer blue-black cortex and an inner very lightly staining medulla. There are also smaller homogeneously stained Golgi spheres. In smears fixed with Flemming without acetic acid and stained with sudan black, the Golgi bodies show a homogeneous structure; but very rarely an incomplete investing rim is seen around a lightly staining medulla. In Helly's post-chromed-hæmatoxylin preparations the Golgi bodies appear exactly as in Helly's post-chromed fixation followed by sudan black. Hæmatoxylin stains the Golgi bodies as dark homogeneous spheres when preceded by chrome-osmium fixatives. They can be stained with acid fuchsin (Masson's triple stain).

In Kolatchev preparations the Golgi bodies appear as heterogeneous spheres showing an osmiophilic cortex and an osmiophobic medulla; but the osmiophobic substance becomes greatly swollen up and the spheres become flattened. A few Golgi crescents are also seen as optical sections of the Golgi spheres (Nath[3], Shafiq[1], Roque[2]). In Aoyama preparations also the Golgi spheres, showing a duplex structure, come up beautifully in finished sections; but invariably artefacts, in the form of black granules on or around the Golgi spheres, appear.

Regaud's post-chromed-hæmatoxylin preparations generally show duplex Golgi bodies; but these preparations also show neurofibrillae as described by Beams and King[4]. The Golgi bodies are completely washed out in Bouin's fluid.

Thus the Golgi bodies described by me appear to be identical with the lipochondria of Shafiq[1]. Similar osmiophil bodies (rings, semicircles, crescents and rods) have been described as Golgi bodies by Beams and King[4] and Beams *et al.*[5]. But Shafiq did not observe any neurofibrillæ.

Laccotrephes rubra. The Golgi bodies of the thoracic neurones of this water-bug are almost similar to the

'binary spheroids' of *Helix* (Thomas[6]). It has been observed that in this material there is generally a granule or a crescent attached to a vacuole. The granule or the crescent appears as a dark, highly refractile component attached to the vacuole in the living neurones examined under phase-contrast, whereas the vacuoles are seen as colourless bodies (Fig. 2). The granular or crescent-shaped component of the Golgi body appears to be lipoidal in constitution, as it is stained by sudan black. It also reduces osmium and silver. It is darkly stained by hæmatoxylin preceded by chrome–osmium fixatives. The vacuole can be stained with the vital dye, neutral red. When the vacuoles are homogeneously stained with this dye, it becomes difficult to see the lipoidal component. The optimum impregnations of osmium or silver do not impregnate the vacuoles; and they are also not stained by sudan black. It is thus clear that the lipoidal cortical component of the 'binary spheroids' of Thomas[6] represents the Golgi material, and the vacuolar part of the spheroid the vacuome of Parat.

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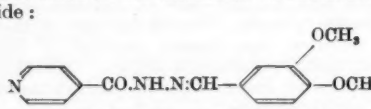
Anti-Tuberculous Activity of Verazide (1-*iso*Nicotinoyl-2-veratrylidene Hydrazine)

The high *in vitro* activity of 1-*iso*nicotinoyl-2-veratrylidene hydrazine (0·06 μgm. per ml.), henceforth referred to as verazide, has been previously reported by us[1] and others[2,3]. Fox and Gibas[4] report that 2 : 2-alkylidene derivatives of isoniazid (among which was included verazide) were markedly tuberculostatic in mouse tuberculosis. There is no reference, however, to the degree of activity of verazide or to its activity when given by intermittent dosage.

This report deals with the *in vivo* action of verazide and directs attention to its prolonged action and potential value in the treatment of tuberculosis. As verazide:



1-*iso*Nicotinoyl-2-veratrylidene hydrazine

is an insoluble derivative of isoniazid, it was decided to test its *in vivo* action by intermittent dosing at weekly, fortnightly and monthly intervals, using the healing ulcer technique previously described by one of us[5]. In addition, isoniazid was included for comparison. The results are shown in Table 1.

We have already shown[5] that a chemotherapeutically interesting anti-tuberculous agent is capable of scoring a healing ulcer value of 50 after 28 days treatment. Thus, verazide given in doses as low as 10 mgm./kgm. at weekly intervals exhibits a fair degree of activity, and at 30 mgm./kgm. is capable of effecting an almost complete healing of tuberculous ulcers with only three injections. At higher doses more widely spaced, for example, at 14–28-day intervals, the high degree of activity is maintained. Interestingly enough isoniazid, which is completely excreted in 24 hr. in animals[6] and man[7], is highly active (healing ulcer value 95) when 30 mgm./kgm. is given at weekly intervals. In the treatment of human tuberculosis, however, isoniazid is not given in doses exceeding 5–8 mgm./kgm. because of its toxicity.

Table 1. Anti-tuberculous Activity of Verazide *in vivo*

Drug	Dosage (mgm./kgm. body-weight)	Route	No. of doses	No. of animals	H.R. value* after 28 days treatment
Verazide	5 mgm. weekly	Intramus. inject.	4	4	15 (inactive)
Verazide	10 mgm. weekly	Intramus. inject.	4	4	58 (fair activity)
Verazide	15 mgm. weekly	Intramus. inject.	4	4	61 (fair activity)
Verazide	30 mgm. weekly	Intramus. inject.	3	4	98 (high activity)
Verazide	30 mgm. weekly	*Per os*	4	4	78 (moderate activity)
Verazide	30 mgm. fortnightly	Intramus. inject.	2	4	73 (moderate activity)
Verazide	45 mgm. fortnightly	Intramus. inject.	2	4	92 (high activity)
Verazide	60 mgm. monthly	Intramus. inject.	1	4	77 (moderate activity)
Isoniazid	30 mgm. weekly	Intramus. inject.	4	4	95 (high activity)

* H.R. value = percentage cure of tuberculous lesions as measured by the healing ulcer technique (ref. 5).

Determination of acute toxicity by intraperitoneal injection of mice showed that the LD_{50} of isoniazid was 200 mgm./kgm. body-weight, whereas the LD_{50} of verazide was 700 mgm./kgm.

To summarize these results, verazide is highly active in the treatment of established tuberculosis in the guinea pig when given in intermittent doses either at 7-, 14- or 28-day intervals. It is active when given by mouth, but to a lesser degree than by injection. Finally, verazide is only one-third as toxic as isoniazid when measured by acute toxicity for mice. These findings will be reported and extended elsewhere.

We wish to thank Miss Janice Edgar and Mr. J. Buttifant for their assistance.

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Aug. 17.

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[6] Rubin, Hassert, Thomas and Burke, *Amer. Rev. Tuberc.*, **65**, 392 (1952).
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Overcoming Cross-Incompatibility among some Mexican Diploid Species of *Solanum*

Species of *Solanum* belonging to the section *Tuberarium* and occurring in Mexico have long been of interest to potato breeders, as several of them possess resistance to the late-blight caused by *Phytophthora infestans* de Bary. Like the tuber-bearing species of *Solanum* found in South America, the Mexican species also form a polyploid series comprising diploids ($2n = 24$), triploids ($2n = 36$), tetraploids ($2n = 48$), pentaploids ($2n = 60$) and hexaploids ($2n = 72$). These species have been classified

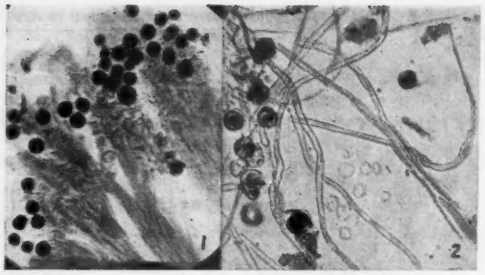

Fig. 1. Stigma and part of style of *S. pinnatisectum*, 72 hr. after pollination with *S. lanciforme* pollen. There is practically no germination of pollen

Fig. 2. Pollen of *S. bulbocastanum* germinated on an agar–sucrose–gelatin medium

in eight distinct taxonomic series, and our information concerning the cytogenetic affinities among them is still very fragmentary. As a preliminary towards gathering such data, a systematic survey of ability to cross among the diploid species occurring in Mexico was undertaken by me, during the summer of 1953, at the Inter-regional Potato Introduction Station, Sturgeon Bay, Wisconsin.

The following diploid species were used in the study: *S. pinnatisectum* (series *Pinnatisecta*), *S. bulbocastanum* (series *Bulbocastana*), *S. lanciforme* (series *Cardiophylla*) and *S. polyadenium* (series *Polyadenia*). In the first set of crosses made in the usual way (emasculation followed by controlled pollination), only the cross *S. pinnatisectum* × *S. polyadenium* succeeded. A study was then made of the causes for the failure of seed-setting in the crosses *S. pinnatisectum* × *S. bulbocastanum* and *S. pinnatisectum* × *S. lanciforme*. For this purpose, the ovaries with style and stigma were fixed in Carnoy's solution (alcohol, acetic acid, chloroform, 6 : 1 : 3), 24, 36, 48, 72 and 120 hr. after pollination, sectioned and stained with acid fuchsin and light-green. Examination of the slides revealed that in both crosses there was little or no germination of the respective pollen on the stigma even after 72 hr. from the time of pollination (Fig. 1). This duration is usually found to be sufficient to allow fertilization in compatible crosses. In the few germinated pollen grains the length of the tubes was only about three times the diameter of the pollen.

To overcome the pollen-stigma incompatibility, two techniques were tried, namely, smearing the stigmatic exudation from the pollen parent on the stigma of the pistillate parent, before pollination, and applying a suitable artificial medium for pollen germination on the cut surface of the style after removal of the stigma. An intermediate method described below led to the formation of berries and seeds in both crosses. The stigma, with a small portion of the style, was removed with a pair of fine scissors from the flowers of *S. pinnatisectum*, and a drop of an agar–sucrose–gelatin medium was applied to the decapitated surface of the style. This medium was prepared by dissolving 0·5 gm. of agar and 2·5 gm. of sucrose in 25 c.c. of distilled water to which 0·5 gm. of gelatin was added. The pollen grains of many species of *Solanum* were found to grow well in this medium (Fig. 2). After applying pollen to this medium on the cut surface of the style, the cut style was covered with a piece of moist cotton wool. From the crosses *S. pinnatisectum* × *S. lanciforme* and *S. pinnatisectum* × *S. bulbocastanum* thus made, four and three berries containing on an average thirty-nine and eight seeds respectively were obtained. Seeds from these crosses were grown at the Inter-regional Potato Introduction Station, Sturgeon Bay, in the summer of 1954 by Dr. R. W. Hougas, who found that the plants were real hybrids.

Such crosses have been attempted previously by several workers in different countries but without success[1]. The hybrid between *S. pinnatisectum* and *S. bulbocastanum* may be of particular interest to potato breeders as a valuable breeding stock, since Niederhauser and Mills[2] have recently reported that *S. bulbocastanum* is not only resistant to late blight but is also probably the only species immune to it.

This investigation was supported by a grant from the Research Committee of the Graduate School with funds provided by the Wisconsin Alumni Research Foundation. I thank Drs. D. C. Cooper, G. H. Rieman and R. W. Hougas for advice and help during the course of the study.

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[1] Swaminathan, M. S., and Howard, H. W., *Bibliographia Genetica* **16**, 1 (1953).

[2] Niederhauser, J. S., and Mills, W. R., *Phytopath.*, **43**, 456 (1953).

The Pogonophora

A report has recently been published in the daily Press alleging that Russian zoologists have lately discovered a new phylum of animals, the Pogonophora. This is, of course, a mistake, and in the paper by A. V. Ivanov, published in *Systematic Zoology*, **3**, 69 (1954), and in *Dokl. Akad. Nauk S.S.S.R.*, **100**, 175, 381, 595 (1955), acknowledgment is generously made to all previous workers on this interesting group. The animals have been known for some time; but Ivanov has created a new phylum for them, and this may have caused the misunderstanding.

Pogonophora are elongated tubicolous animals the body of which is composed of a short anterior portion bearing tentacles and a very long trunk. The anterior portion contains two pairs of cœlomic cavities of which the first contain so-called nephridia and the second are continuous with the cavities of the tentacles. The trunk contains a third pair of cœlomic cavities in which lie the gonads. The hinder part of the trunk shows repeated ring-shaped papillæ of chitinous platelets serving as adhesive organs. A dorsal nerve centre is present; but no trace has hitherto been found of gut, mouth or anus.

Although so much remains to be discovered in these animals, it is quite possible that Caullery and Ivanov are right in looking for their affinities among those groups which include the Enteropneusta. The tripartite arrangement of the cœlom and the dorsal nerve centre immediately suggest this. Details will be eagerly awaited regarding the structure of the so-called nephridium before it will be possible to compare it with the nephridium of the actinotrocha larva of *Phoronis*. Altogether, enough is known of these organisms to whet the appetite for more, and the results of Prof. Ivanov's further investigations will be awaited with interest.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 7

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. Charles Sadron (Strasbourg): "The Morphology of Large Chain Molecules".*

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "Lagrange's Principle as the Basis of a Unified Treatment of the Action of Electrical Indicating Instruments".

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (joint meeting with the INSTITUTE OF METALS, LONDON SECTION, at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.15 p.m.—Dr. N. P. Inglis: "The Production and Properties of Titanium and its Alloys".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (joint meeting with the ASSOCIATION OF PUBLIC ANALYSTS, at the Linnean Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Prof. Charles Wesley Dunn (U.S.A.): "The United States Federal Food, Drug and Cosmetic Law".

ROYAL GEOGRAPHICAL SOCIETY (joint meeting with the ALPINE CLUB, at the Royal Festival Hall, London, S.E.1), at 8.30 p.m.—Mr. Charles Evans and Mr. George Band: "Kanchenjunga Climbed".

Tuesday, November 8

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in Room 105, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 1 p.m.—Dr. P. J. Fensham: "Communications and Supervisory Organisation during a Period of Automatic Innovation".

ZOOLOGICAL SOCIETY OF LONDON (in the Mappin Refreshment Pavilion, Mappin Terrace, Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Meeting.

ROYAL SOCIETY OF ARTS, COMMONWEALTH SECTION (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Mr. Arthur Gaitskell: "The Gezira Scheme".

UNIVERSITY OF LONDON (at the Royal College of Science and Technology, South Kensington, London, S.W.7), at 5.30 p.m.—Prof. A. W. Skempton: "The Development of Soil Mechanics and its Place in the University" (Inaugural Lecture).

UNIVERSITY OF LONDON, BRITISH POSTGRADUATE MEDICAL FEDERATION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Dr. O. G. Edholm: "The Effect of Cold on Man". (Fourth of fifteen Lectures on "The Scientific Basis of Medicine".)*

ILLUMINATING ENGINEERING SOCIETY (at the Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 6 p.m.—Mr. F. Jackson, Mr. R. Molloy and Mr. K. Scott: "Efficiency of Fluorescent Lamps".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. M. Hurel: "High Aspect Ratio Wings".

INSTITUTE OF METALS (at the Royal Institution, Albemarle Street, London, W.1), at 8.30 p.m.—Prof. Cyril S. Smith (University of Chicago): "The Shape of Grains in Single-Phase and Two-Phase Alloys".*

Wednesday, November 9

INSTITUTE OF METALS (at the Royal Institution, Albemarle Street, London, W.1), at 10 a.m.—Symposium on "The Mechanism of Phase Transformations in Metals".

UNIVERSITY OF LONDON (at the Postgraduate School of Medicine, Ducane Road, London, W.12), at 2 p.m.—Dr. P. Fourman: "Salt and Water Metabolism".*

PHYSICAL SOCIETY, COLOUR GROUP (at the Institute of Ophthalmology, Judd Street, London, W.C.1), at 3.30 p.m.—Mr. E. H. Leach: "Structure of the Retina and Colour Vision"; Dr. W. A. H. Rushton, F.R.S.: "The Physical Measurement of Human Cone Pigments in the Normal and the Colour Blind".

INSTITUTE OF FUEL (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Mr. J. E. Hawkins and Mr. G. Nonhebel: "Chimneys and the Dispersal of Smoke".*

INSTITUTE OF PETROLEUM (at 26 Portland Place, London, W.1), at 5.30 p.m.—Prof. F. H. Garner, Mr. G. H. Grigg, Prof. F. Morton and Dr. W. D. Reid: "Preflame Reaction in a Diesel Engine".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. G. B. B. Chaplin, Mr. R. E. Hayes and Mr. A. R. Owens: "A Transistor Digital Fast Multiplier with Magneto-Strictive Storage".

SOCIETY FOR WATER TREATMENT AND EXAMINATION (joint meeting with the INSTITUTION OF HEATING AND VENTILATING ENGINEERS, at the Institution of Mechanical Engineers, Storey's Gate, London, S.W.1), at 5.30 p.m.—Symposium on "Corrosion".

UNIVERSITY COLLEGE LONDON (in the Physiology Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. Sven Hörstadius (University of Uppsala): "On the Determination of the Bilateral Symmetry in the Sea-Urchin Egg".*

SOCIETY FOR ANALYTICAL CHEMISTRY, MICROCHEMISTRY GROUP (at The Feathers, Tudor Street, Strand, London, E.C.4), at 6.30 p.m.—Discussion on "The Determination of Carbon and Hydrogen".

Thursday, November 10

ROYAL SOCIETY (at Burlington House, London, W.1), at 4.30 p.m.—Mr. R. A. Bagnold, F.R.S.: "The Flow of Cohesionless Grains in Fluids"; Mr. B. R. Morton, Sir Geoffrey Taylor, F.R.S., and Mr. J. S. Turner: "Turbulent Gravitational Convection from Maintained Sources".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. T. H. Kinman, Mr. G. A. Carrick, Mr. R. G. Hibberd and Mr. A. J. Blundell: "Germanium and Silicon Power Rectifiers".

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGY GROUP (joint meeting with the AGRICULTURE and PESTICIDES GROUPS, at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 6.15 p.m.—Dr. N. F. Robertson: "Disease Resistance in Plants".

Friday, November 11

PHYSICAL SOCIETY, ACOUSTICS GROUP (in the Physics Department, Imperial College, Imperial Institute Road, London, S.W.7), at 5.30 p.m.—Dr. E. G. Richardson: "The Acoustic Interferometer".

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (in the Lecture Theatre, Mining Institute, Neville Hall, Newcastle-upon-Tyne), at 6.15 p.m.—Prof. L. C. Burrill: "The Optimum Diameter of Marine Propellers: A New Design Approach".

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 7 p.m.—Mr. A. R. Powell, F.R.S.: "The Procurement of Some Hitherto Rare Metals".

UNIVERSITY OF LONDON (at Wye College, Wye, near Ashford, Kent), at 8.15 p.m.—Sir Mortimer Wheeler: "The Story of the Ancient Britons".*

Saturday, November 12

BRITISH PSYCHOLOGICAL SOCIETY (joint meeting with the SOCIAL PSYCHOLOGY SECTION, in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 2 p.m.—Mr. W. A. Belson "Learning and Attitude Changes Produced by a Television Broadcast, with Special Reference to Research Method"; Mr. Alexander Mitchell: "The Content of Communication"; Mr. P. L. Short: "The Development of Some Experimental Techniques for Obtaining Viewers' Reactions to T.V. Films"; Dr. Eunice Belbin: "The Effect of Propaganda on Recall, Recognition and Behaviour".

BRITISH INTERPLANETARY SOCIETY (in the York Hall, Caxton Hall, Caxton Street, London, S.W.1), at 6 p.m.—Dr. J. M. K. Kooy: "Space Travel and Future Research into the Structure of the Universe" (Overseas Lecture).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SENIOR LECTURER or LECTURER (with teaching, research and/or industrial experience, preferably with research or industrial experience of electronic circuits) IN PHYSICS—The Clerk to the Governors, Chelsea Polytechnic, Manresa Road, London, S.W.3 (November 10).

RESEARCH ASSISTANT (graduate in civil engineering) IN PUBLIC HEALTH ENGINEERING, for work forming part of an extensive programme of research in aspects of public health engineering—The Registrar, King's College, Newcastle-upon-Tyne (November 12).

LECTURER IN PHARMACOLOGY—Registrar, King's College, Strand, London, W.C.2 (November 15).

LECTURER IN FUEL TECHNOLOGY AND CHEMICAL ENGINEERING—The Registrar, The University, Sheffield (November 19).

SENIOR RESEARCH OFFICER (with laboratory experience in the diagnosis and investigation of diseases of equines, especially mares and new-born foals, and ability to organize a service covering diagnosis, investigation, research and advice on such diseases) AT THE VETERINARY RESEARCH LABORATORY, Dublin—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin (November 22).

PROFESSOR OF ENGINEERING at the University of Ceylon—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Ceylon, November 24).

DIRECTOR OF THE WEST AFRICAN INSTITUTE OF SOCIAL AND ECONOMIC RESEARCH, University College, Ibadan—The Secretary, Inter-University Council for Higher Education Overseas, 1 Gordon Square, London, W.C.1 (November 30).

LECTURER (graduate, with special interest in surveying) IN CIVIL ENGINEERING—The Registrar, King's College, Strand, London, W.C.2 (November 30).

LECTURER IN GEOGRAPHY—The Secretary of University Court, Glasgow (December 1).

CHAIR OF BUILDING SCIENCE—The Registrar, The University, Liverpool (December 10).

LECTURER IN METALLURGY in the Faculty of Engineering—The Secretary and Registrar, The University, Southampton (December 15).

CHAIR OF BACTERIOLOGY—The Secretary, The University, Edinburgh (December 31).

ASSISTANT EXPERIMENTAL OFFICER (with training in agricultural science), for research work on the nutrition of grazing animals—The Secretary, Rowett Research Institute, Bucksburn, Aberdeen.

CHEMIST (with first- or second-class honours degree, or equivalent qualification, and at least three years general industrial experience, preferably with a knowledge of liquid fuels and lubricants), at the Central Laboratory, Chiswick—The Recruitment and Training Officer, London Transport, 55 Broadway, London, S.W.1, quoting F/EV.550.

LECTURER (graduate of a British university, preferably with an interest in electromagnetic theory and teaching experience) IN MATHEMATICS, to teach to final B.Sc. degree standard—The Clerk, Northern Polytechnic, Holloway, London, N.7.

PRODUCE OFFICER (with a university degree in commerce, economics or agriculture and with administrative ability, preferably with experience of inspection and grading of agricultural products) with the Government of the Western Region, Nigeria—Crown Agents, 4 Millbank, London, S.W.1, quoting MIB/35384/TA.

SENIOR LECTURER (with practical experience and extensive chemical knowledge of both thermo-setting and thermo-plastic resins) IN PLASTICS TECHNOLOGY—The Clerk, National College of Rubber Technology, Northern Polytechnic, Holloway, London, N.7.

SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS (with a first- or second-class honours degree in physics or electrical engineering, or equivalent qualification, preferably with experience in the field of spark and arc discharge phenomena, plasma research or particle acceleration; for senior posts at least three years postgraduate research experience is necessary), to study problems associated with the production and acceleration of charged particles—Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 782/34.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Planning. Vol. 21, No. 384 (8 August 1955): Balance Sheet of the Press. Pp. 141–154. (London: Political and Economic Planning, 1955.) 2*s.* 6*d.* [108

Christendom or Christianity: Which One is "the Light of the World"? Pp. 32. (London: Paddington Congregation of Jehovah's Witnesses, 1955.) [108

Medical Association for the Prevention of War. Bulletin Supplement (July, 1955): Proceedings of the Annual Conference, 1955—Medical Effects of Radioactivity. Pp. 12. (London: Medical Association for the Prevention of War, 1955.) 1*s.* [108

Report by the Hydrographer of the Navy on the Surveys carried out by H.M. Naval Surveying Service, and of the work of the Hydrographic Department for the year 1954. Pp. 12. (H.D. 501.) (London: Admiralty, 1955.) [108

Ministry of Fuel and Power. Reports of H.M. Inspectors of Mines under the Coal Mines Act, 1911, for the year 1954. Scottish Division. By W. Widdas. Pp. ii+29+4 plates. (London: H.M. Stationery Office, 1955.) 2*s.* net. [108

Journal of Electronics. Vol. 1, No. 1 (July 1955). Pp. 102. (London: Taylor and Francis, Ltd., 1955.) 20*s.* (Subscription price per volume (6 parts), 110*s.*) [108

National Union of Journalists. Freelance Directory, 1955. Pp. 59. (London: National Union of Journalists, 1955.) [108

The Application of Nipa Products as Preservatives, Antiseptics and Antioxidants in the Cosmetic and Allied Industries. Pp. 20. (London: Nipa Laboratories, Ltd., 1955.) [108

British Electrical and Allied Industries Research Association. Technical Report L/T284: Self-energy of Electrons in Lattice Fields By M. Gurari. Pp. 8. 9*s.* Technical Report L/T312: Electrons in Polar Materials. By M. J. Buckingham. Pp. 7. 6*s.* Technical Report Z/T86: Initial "Acceleration" and "Deceleration" in Novae and Solar Flares. By C. E. R. Bruce. Pp. 5. 4*s.* 6*d.* Supplement to Technical Report Z/T86: Initial "Acceleration" and "Deceleration" in Novae and Solar Flares. By C. E. R. Bruce. Pp. 7. 6*s.* (Leatherhead: British Electrical and Allied Industries Research Association, 1951–1955.) [108

Forestry Commission. Bulletin No. 25: Studies of North-West American Forests in relation to Silviculture in Great Britain. By R. F. Wood. Pp. iv+43+35 photographs. 6*s.* net. Thirty-fifth Annual Report of the Forestry Commission for the year ended September 30th 1954. Pp. 88. 3*s.* 6*d.* net. (London: H.M. Stationery Office, 1955.) [108

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London School of Hygiene and Tropical Medicine. (The Ross Institute—Industrial Advisory Committee.) Bulletin No. 1 (Re-written June, 1955): Residual Insecticides. By G. Davidson. Pp. 31. Bulletin No. 10 (July, 1955): Water. By Dr. R. Ford Tredre. Pp. 31. (London: London School of Hygiene and Tropical Medicine, 1955.) [108

Department of Scientific and Industrial Research. Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology, for the year 1954, with the Report of the Geological Survey Board and Report of the Director. Pp. iv+88. (London: H.M. Stationery Office, 1955.) 3*s.* 6*d.* net. [108

Transport. Pp. 15+4 plates. (London: Unilever Limited, 1955.) [108

Scottish Society for Research in Plant-Breeding. Scottish Plant Breeding Station Annual Report, 1955. Pp. 36+10 plates. (Roslin: Scottish Society for Research in Plant Breeding, 1955.) [108

Esso Petroleum Company Limited. Annual Review, 1954. Pp. 31. (London: Esso Petroleum Company, Ltd., 1955.) [108

Discovery Reports. Vol. 27, Pp. 293–302, plates 14–18: The Wax Plug in the External Auditory Meatus of the Mysticeti. By P. E. Purves. (Cambridge: At the University Press, 1955. Issued by the National Institute of Oceanography.) 10*s.* 6*d.* net. [108

Other Countries

University of Illinois. Engineering Experiment Station. Circular No. 66: The Axial Variation of the Magnetic Field in Solenoids of Finite Thickness. By Prof. Dillon E. Mapother and Prof. James N. Snyder. Pp. 93. 1 dollar. Bulletin No. 428: Strength in Shear of Reinforced Concrete Beams. By Armas Laupa, Prof. Chester P. Siess and Prof. Nathan M. Newmark. Pp. 73. 1 dollar. Bulletin No. 429: Observed and Computed Settlements of Structures in Chicago. By Prof. B. Peck and Mehmet Ensar Uyanik. Pp. 60. 90 cents. Bulletin No. 430: Stresses around Mine Openings in Some Simple Geologic Structures. By R. D. Caudle and Prof. G. B. Clark. Pp. 42. 65 cents. (Urbana, Ill.: University of Illinois, 1955.) [108

Department of Agriculture, Ottawa. Report of the Director of Science Service for the year ended March 31, 1954. Pp. 64. (Ottawa: Queen's Printer, 1955.) [108

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Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Série Scientifique No. 64 (1955): Observations sur la Genèse des Nappes de Gravats dans les Sols Tropicaux. Par D. de Heinzelin. Pp. 37. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1955.) 30 francs. [108

United States Department of Agriculture. Farmers' Bulletin No. 2082: Commercial Production of Greenhouse Tomatoes. By William S. Porte and Floyd F. Smith. Pp. 30. 15 cents. Technical Bulletin No. 1110: Studies of Airplane Spray-Deposit Patterns at Low Flight Levels. By Joseph C. Chamberlin, Charles W. Getzendaner, Harold H. Hessig and V. D. Young. Pp. ii+45. 25 cents. (Washington, D.C.: Government Printing Office, 1955.) [108

National Research Development Corporation of India. First Annual Report and Statement of Accounts for the period ending 31st March, 1955. Pp. 17. (New Delhi: National Research Development Corporation of India, 1955.) [108

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